



Mid-Atlantic  
Field Guide to

# Aquatic Invasive Species



## Acknowledgements

Developed by Sara Stahlman, Pennsylvania Sea Grant, [sng121@psu.edu](mailto:sng121@psu.edu)

Graphic design by Graphics and Design, State College, PA

**A very special thank you** to the Mid-Atlantic Panel on Aquatic Invasive Species (MAPAIS) for funding this project and to the members of MAPAIS, in particular Mike Allen, Ray Fernald, Fredrika Moser, Jonathan McKnight, Sarah Whitney, and to all others who contributed materials, reviewed, edited, and provided feedback and advice on this project. Appreciation is also extended to the photographers and artists who contributed their images for the benefit of this project.

The Mid-Atlantic Field Guide to Aquatic Invasive Species was made possible by funding provided by MAP through grant F12AP01037 from the U.S. Fish and Wildlife Service.

# Mid-Atlantic Field Guide to Aquatic Invasive Species

## Table of Contents

|     |   |
|-----|---|
| 2   | Introduction                            |
| 4   | About MAPAIS                            |
| 5   | Regional Challenges                     |
| 6   | Using the Field Guide                   |
| 8   | Prevention                              |
| 10  | Reporting and Collecting                |
| 12  | <b>Invasive aquatic plants</b>          |
| 56  | <b>Invasive wetland plants</b>          |
| 98  | <b>Invasive invertebrates</b>           |
| 136 | <b>Invasive mammals and birds</b>       |
| 146 | <b>Invasive fish</b>                    |
| 184 | <b>Invasive pathogens</b>               |
| 190 | <b>Invasive algae</b>                   |
| 202 | <b>Invasive reptiles and amphibians</b> |
| 208 | Field Guide References                  |
| 221 | Image Credits                           |
| 229 | Glossary                                |
| 233 | Common Name Index                       |
| 234 | Scientific Name Index                   |



# Introduction

---



Aquatic invasive species (AIS) pose a significant environmental and economic threat to the ecosystems and communities of the Mid-Atlantic region and beyond. The Mid-Atlantic region encompasses eight states, including New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, and North Carolina, as well as Washington D.C. The region is home to the Chesapeake Bay; the largest estuary in the United States, with more than 150 major rivers and streams flowing into its 64,299-square-mile basin. In the Chesapeake Bay watershed alone, nearly 200 known or possible invasive species have been recorded.

Global trade, human activities, recreation, and climate change are helping invasive species spread at accelerated rates. Once established, controlling their spread is both technically difficult and expensive, making eradication nearly impossible. Therefore, identifying and preventing the introduction of these species is the key to averting long-term ecosystem damage, and to ensuring the highest probability of effective control.

---

This field guide is designed to aid science professionals and other interested individuals in AIS early detection and reporting. This reference can help water conservation officers, regional biologists, volunteer monitors, resource managers, educators, students, and other professionals working in the Mid-Atlantic's waters to learn general information about significant AIS, identify the problem species, collect specimens for verification, and report new infestations.

This field guide is designed to aid science professionals and other interested individuals in AIS early detection and reporting.

The 99 species included in this field guide were selected by the Mid-Atlantic Panel on Aquatic Invasive Species. Experts compiled a list of species they felt were of most concern to the Mid-Atlantic region. Additional species may be included as needed in future iterations of the guide. Information on all reported species in the Mid-Atlantic Region can be found in the USGS Nonindigenous Aquatic Species database (<http://nas.er.usgs.gov/queries>) and searching by major drainage area. The Mid-Atlantic is HUC2 number 2.



## About MAPAIS

---

# Mid-Atlantic Panel on Aquatic Invasive Species



The Mid-Atlantic Panel on Aquatic Invasive Species (MAPAIS) was formed in 2003 through the efforts of the Chesapeake Bay Program's Invasive Species Workgroup, which identified and ranked invasive species threats to the Chesapeake Bay region. The Workgroup and its member agencies recognized the need for greater coordination of AIS programs throughout the Mid-Atlantic region. Thus, MAPAIS was established as one of six regional panels administered by the Aquatic Nuisance Species Task Force, an intergovernmental organization dedicated to preventing and controlling aquatic nuisance species as authorized by the Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA) of 1990.

MAPAIS has a diverse membership representing state and federal agencies, academic institutions, environmental organizations, commercial interests, and regional entities. Its mission is to assist state and federal agencies, and other stakeholders, in developing and implementing strategic, coordinated, action-oriented approaches to prevent and control the introduction and spread of aquatic invasive species in the Mid-Atlantic region. More information on MAPAIS can be found at [www.midatlanticpanel.org](http://www.midatlanticpanel.org).

The Mid-Atlantic Field Guide to Aquatic Invasive Species was made possible by funding provided by MAPAIS through a grant from the U.S. Fish and Wildlife Service.

# Regional Challenges

---

The Mid-Atlantic Field Guide to Aquatic Invasive Species is a multi-state resource that provides an overview of species information relevant to AIS in the region. However, each state has different regulatory, policy, and management challenges for AIS. For instance, states have specific lists of prohibited/allowed species, unique reporting mechanisms, and different handling and transportation regulations. Some species not included in this guide are considered locally invasive within individual states but are less of a concern across the region. Additionally, some non-native species are considered important sportfish in some areas, but invasive in others.

It is important to consult with your appropriate state agency for the most up-to-date information on local AIS issues. A national database of state contact information is available at [https://www.fws.gov/fisheries/NAS\\_Hotline.html](https://www.fws.gov/fisheries/NAS_Hotline.html).



# Using the Field Guide

---

The purpose of this guide is to help slow or stop the spread of invasive species in the Mid-Atlantic region. Therefore, in addition to identification, it includes sections on prevention, reporting, and collecting specimens.

The focus of the first section is prevention, since it is important that readers understand how to avoid AIS introduction and spread to new locations. It highlights significant vectors of spread for AIS and describes preventative actions that can be taken.

The second section focuses on how to report species. It is important that new infestations are reported quickly and accurately, and that specimens are collected correctly so that subsequent control or management actions can be taken.

The last section contains “species profiles” that highlight important characteristics to help distinguish AIS from other species.

Species are grouped together into larger taxonomic groups, with a different color representing each group:

- **Invasive aquatic plants (dark green)**
- **Invasive wetland plants (light green)**
- **Invasive invertebrates (teal)**
- **Invasive mammals and birds (purple)**
- **Invasive fish (blue)**
- **Invasive pathogens (orange)**
- **Invasive algae (yellow)**
- **Invasive reptiles and amphibians (maroon)**

Species are ordered alphabetically by common name. Each profile contains photographs, illustrations, maps, and narrative descriptions to highlight important facts or features of that species.

Profiles follow the general format below:

**Species at a Glance:** Brief overview of species and any interesting facts

**Identification:** Key characteristics for identifying the species

**Similar Species:** Methods for distinguishing invasive species from native look-a-likes

**Habitat:** Description of the preferred environment

**Spread:** Highlights pathways and vectors by which the species can be transferred to new locations

**Distribution:** Native and invasive range information, including distribution in the United States and the Mid-Atlantic region.

**Impacts:** Documented or potential influence on biodiversity, the economy, or human health

### **Additional tips for using the guide:**

- At the beginning of each taxonomic grouping is a reference section with important information for identification.
- Each reference section contains images and diagrams highlighting important anatomical structures and features of the species within that group. Reviewing these features may be helpful for identifying species.
- Definitions for words in **bolded letters** can be found in the glossary on page 229.
- The back cover page of the field guide can be used as a ruler to help measure specimens in the field.
- Distribution information was taken from the USGS Non-Indigenous Species database, the USDA NRCS plants database, iMAP invasives, and other web-based distribution tracking sites. This information represents 2016 data and may not be completely accurate as distribution information goes quickly out of date. Please use additional resources to verify species locations in your area.

**Idc**  
*Leuciscus idus*



**Species at a Glance**  
The **Idc**, also called the **arctic**, is a large-headed freshwater fish and member of the carp family. It is valued as a sport fish in many countries and has been introduced in a number of locations for recreational purposes. Concerns have been raised over its potential to damage native aquatic ecosystems, but more research is needed to determine actual impacts.

**Identification**  
This chunky fish has a distinct arch on the back and belly. The head is small and fairly pointed and the tail has a fork. Its **two color forms** exist, including the **solid form** and **ornamental form**. The **solid form** is a gradient-like color on the back and upper sides, paling to silver on the sides and a sliver white on the belly. Its **head and pelvic fins** are reddish in color. The **ornamental variety** has a bright orange back, silver-orange sides and belly, and a bright orange tail and dorsal fin. These two color morphs are known as **silver** and **golden** side respectively. Golden populations may react to cold colonization over time.

**Similar Species**  
This species may be confused with the European goldfish (*Carassius auratus*), however, the **goldfish**, **golds**, and **Red Eye Gold** do not have an distinctive large mouth protrusion like the **Idc**. In fact, the **Idc** is the only species in the genus *Idus* with a protruding mouth with a tongue that can cover the gape, which is adapted to forage.

**Habitat**  
The **Idc** prefers to inhabit slow, clear ponds of moderate to large water volume. It is found in the **Idc** **Basin** and **Idc** **Basin**. It can also be found in small streams and rivers. It is an omnivorous species with a diet of algae, plants, and the ability to consume benthic invertebrates and detritus.

**Spread**  
Thought to be an ornamental pond fish, the **Idc** has been introduced worldwide to the markets for ornamental purposes and fishing. International release and trade in the **Idc** has also been observed for genetic rescue in **Idc** populations.

**Distribution**  
Native to Europe, the **Idc** was first reported in 1877 in the U.S. in Connecticut in 1918, and introduced to Mississippi in 1926. It is now established in the Mid-Atlantic in the lower Potomac River in Washington and along the Chesapeake Bay. It is also established in the Mid-Atlantic in the lower Potomac River in Washington and along the Chesapeake Bay. It is also established in the Mid-Atlantic in the lower Potomac River in Washington and along the Chesapeake Bay. It is also established in the Mid-Atlantic in the lower Potomac River in Washington and along the Chesapeake Bay.



© Pennsylvania AIS Field Guide

© Pennsylvania AIS Field Guide

Mid-Atlantic AIS Field Guide 7

# Prevention



Preventing the arrival and spread of species into the Mid-Atlantic's waterways is the best way to control their establishment. By taking precautionary steps, the harmful ecological, economic, and health impacts associated with AIS introductions could be prevented or reduced.

AIS can hitchhike on boats, trailers, equipment, fishing tackle, motors, clothing, diving gear, and boots, or in bait buckets, bilges, and live wells. Some species can survive out of water on damp clothing or equipment for several days to weeks, and some are so small they are nearly impossible to detect.

The following section describes common ways that AIS can spread and outlines the prevention measures that can be taken to reduce spread.

## **Boating and angling**

Boats, boat trailers, fishing equipment, waders, and other gear that come in contact with water can transport AIS from one waterbody to another. Microscopic AIS, such as zebra mussel veligers or didymo cells, may be lurking in bait buckets, live wells, or bilges, waiting to be discarded into a new area. Plants tangled around boat motors and trailers can be released into new environments, transforming valuable fishing and boating areas into mangled mats of weeds. Some species may even harm boats by jamming steering equipment, and ruining boat engines. Follow these guidelines to protect waterways of the Mid-Atlantic:

### **Boaters and anglers**

- Inspect and clean off plants, visible aquatic plants, animals, and mud from watercraft, motor, trailer, and gear and equipment including waders, footwear, ropes, anchors, bait traps, dip nets, downrigger cables, fishing lines, and field gear before leaving water access.
- Rinse watercraft, trailer, and equipment with high pressure hot water when possible and use a stiff brush to remove visible material on footwear.
- Drain water from watercraft, motor, bilge, bladder tanks, livewell and portable bait containers before leaving water access.
- Dispose of unwanted bait, fish parts, and packing materials, in the trash; do not dump them in the water or on land.
- Dry everything five days or more, unless otherwise required by local or state laws, when moving between waters to kill small species not easily seen OR wipe with a towel before reuse.

### **For anglers:**

- Use non-felt soled boots to further reduce the risk of spreading AIS.
- Fish caught for eating or taxidermy should be cleaned at designated fish cleaning stations or placed on ice.
- Never dump live fish or other organisms from one water body into another.



## STOP AQUATIC HITCHHIKERS!™

Prevent the transport of aquatic invasive species.  
Clean all recreational equipment.

[www.ProtectYourWaters.net](http://www.ProtectYourWaters.net)

### Diving and swimming

- Check all gear that was in contact with water (including regulators, buoyancy compensators [BCs], wetsuits, masks, snorkels, and any other dive gear).
- Thoroughly clean all diving gear, including both the inside and outside of the BC, to ensure that no mud or organic matter is present.
- After cleaning, soak equipment and inside of BC with hot water\* or salt water (1/2 cup salt/gallon) for 30 minutes. Because salt can harm equipment, be sure to thoroughly rinse with freshwater after cleaning.
- Allow clothing, gear, and other equipment to dry completely before entering different waters.

### Aquarium and water garden animals and plants

Never release unwanted pets or aquarium plants into the environment. If a pet or plant is no longer wanted, or can no longer be cared for, choose from one of the following alternatives:

- Contact a local retailer for proper handling advice or for possible returns.
- Give/trade with another aquarist, pond owner, or water gardener.
- Donate to a local aquarium society, school, or aquatic business.
- Seal aquatic plants in plastic bags and dispose in trash.
- Contact a local pet store, humane society, veterinarian, or other expert for guidance on appropriate and humane disposal options.

In addition, never dump live plants and/or aquatic animals into storm drains. Storm drains lead to rivers, lakes, or wetlands, which are all integral components of a bigger watershed. For more information, visit [habitattitude.net](http://habitattitude.net).

### Aquatic biologists, monitors, and those working in waterways and wetlands in the Mid-Atlantic region

To reduce potential AIS spread, field workers should take the following precautionary measures during activities such as monitoring, collecting, surveying, and fish stocking:

- Inspect and remove aquatic plants, animals, seeds, and mud from boat, trailer, anchors, waders, boots, nets, and all equipment, paying particular attention to cracks and crevices.
- Drain lake or river water from motor or jet drive, bilge, live wells, tubs, tanks, and sampling equipment before leaving water access.
- Dispose of unwanted plants, fish, worms, crayfish, snails, or clams in the trash.
- Wash boat, motor, trailer, and personal gear (waders, boots, scuba gear) and field sampling equipment (nets, bottles, ropes, tubs) with high pressure, hot tap water\*, OR
- Dry boat, motor, and trailer in the sun for at least five days and equipment for at least 10 days, or freeze for at least two days before reuse.

Visit [protectyourwaters.net](http://protectyourwaters.net) and [wildlifeforever.org](http://wildlifeforever.org) for more information on AIS prevention.

# Reporting & Collecting

---

## Reporting a Sighting

The information presented in this section represents general steps to follow to ensure proper early detection and response for potential new AIS discoveries. This information may not be applicable to all states in the Mid-Atlantic; therefore, please look to your own state for guidance on how to handle reporting and collecting specimens.

### **Carry documentation tools to accurately document your finding in the field:**

- Digital camera
- A way to identify the latitude/longitude, such as a map of the area or GPS unit
- Notebook and pen for taking notes
- The Mid-Atlantic Field Guide for assistance in species identification
- Smart phone identification apps such as the Mid-Atlantic Early Detection Network (MAEDN) app

### **Gather and document information accurately:**

- Note the exact location of the discovery, including latitude and longitude, if possible.
- Make notes about the location, habitat, and environmental conditions of the discovery site.
- Take note of the species size and extent of the area it covers.
- Write down a detailed description of unknown specimen(s).
- Take digital photographs of the unknown specimen(s), as well as the immediate environment. Include key landmarks to assist in finding the site.
- Include commonly known items (coins, eyeglasses, or a camera lens cover, etc.) in the photo for a size comparison.
- Use the Mid-Atlantic Field Guide to help identify the species.

### **Verify identification and submit report:**

- To report a sighting or request assistance with identification in your state visit: [https://www.fws.gov/fisheries/NAS\\_Hotline.html](https://www.fws.gov/fisheries/NAS_Hotline.html)

## Collecting a Specimen\*

**Only collect a specimen if it is requested by the agency with authority over AIS in your state.** When a sample specimen is needed to assist in identification, it is important to keep the specimen secure to avoid spreading the collected species, or any organisms that might be attached to it. Please keep a record with the specimen of the location and date that it was collected. Beware that animal specimens may carry disease organisms. Use appropriate prophylactic measures (gloves, handling with forceps, etc.).

*\*Please note: it is illegal to possess or transport certain aquatic invasive species in Mid-Atlantic states. Please review the list of regulated species in your state before handling or transporting.*



### ***Collecting Specimens:***

#### **Aquatic and terrestrial plants:**

- Specimens should include the stem with intact leaves, and if available, intact flowers and/or **fruits** and roots.
- Be very careful when collecting a plant specimen, as **fragmentation** could result in spreading the plant to other areas.
- Wash the plant in water to remove all debris; do not allow the plant to dry out, and keep cool if possible.
- Use care when handling, as some plants may cause skin and other ailments.

#### **Invertebrates (shellfish, worms, or insects):**

- Store specimens in a closed vial or jar with enough rubbing alcohol to keep the tissues moist.

#### **Vertebrates (fish):**

- Seal securely in double plastic bags and freeze.

### ***Mailing specimens:***

When an outside source is needed for identification, refer to the following guidelines for mailing:

#### **Plants:**

- Place the plant in a water-tight plastic bag (such as a Ziploc bag) with enough water to cushion the plant and keep it wet.
- Place the tightly sealed bag in a small box with newspaper packing. Padded envelopes do not work well.

#### **Invertebrates:**

- Package the specimen securely in a small box with plenty of packing materials to ensure the jars are not broken.

#### **Vertebrates:**

- The United States Postal Service has specific standards and requirements regarding the shipment of hazardous materials such as formalin and dry ice. If shipment to a taxonomic expert is necessary for identification, work with the recipient and the postal service to determine the best and safest method for shipping the specimen.

### **BE SURE TO PROVIDE CONTACT INFORMATION**

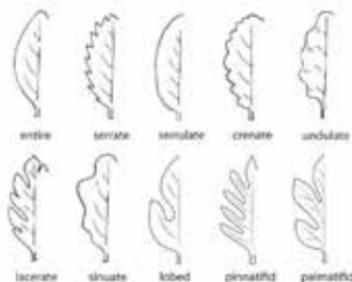
**Always include a copy of your name, address, E-mail address, telephone number, and a copy of the notes you made when collecting the specimen in the mailed package.**

# Plant Structure

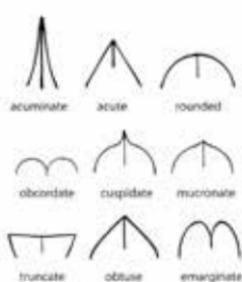
## LEAF SHAPES



## LEAF MARGINS



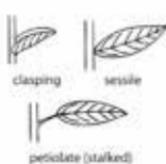
## LEAF TIPS



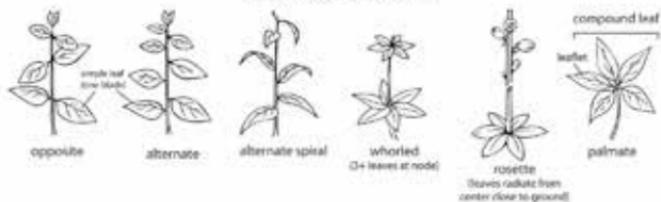
## LEAF BASES

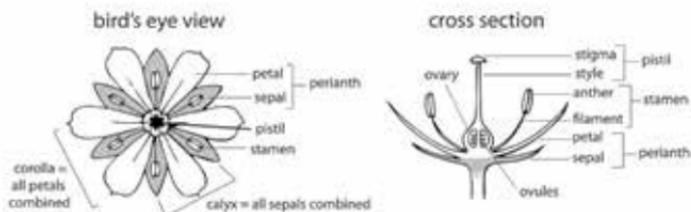
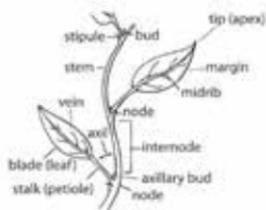


## LEAF ATTACHMENTS

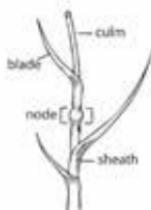


## LEAF ARRANGEMENTS

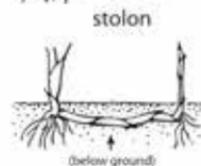
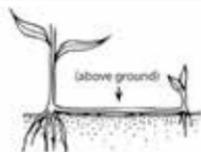


**FLOWER PARTS**

**STEMS**


dicot



monocot



rhizome

**ROOTS**

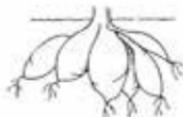

bulb



corm



fibrous



tubers



tap



fleshy

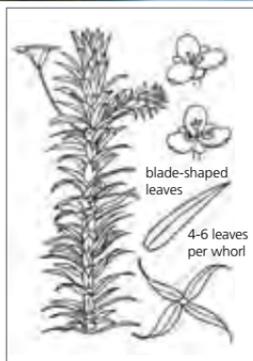
# Brazilian Elodea

*Egeria densa*



## Species at a Glance

Brazilian elodea is a **submerged** aquatic perennial that can reach lengths of 3 m (10 ft) or more, and can survive either rooted or free-floating in depths up to 6.1 m (20 ft). Because of its showy flowers and oxygen generating capabilities, it is widely used as an aquarium plant and is still sold today under its alias “Anacharis”. All introductions in the United States appear to be male plants.



## Identification

**Leaves:** Bright to dark green; densely arranged in **whorls** of 4-6 leaves per **node**, although some lower leaves may occasionally occur in **opposite** pairs or in **whorls** of three leaves. The leaves are robust and blade-shaped, 1-3 cm (0.4-1.2 in) long, and 5 mm (0.2 in) wide. Very fine teeth on the leaf **margins** are only visible with magnification.

**Flowers:** Large showy flowers have three white petals, a yellow center, and three green **sepals**. They emerge above or at the water’s surface on slender **stalks** projecting from leaf **axils** near the stem tips.

**Stems/Roots:** Roots form irregularly along the stems from “double **nodes**,” which are areas where two **whorls** appear to be joined.

## Similar Species

Brazilian elodea may be confused with the invasive plant *Hydrilla verticillata* and the native plant American elodea (*Elodea canadensis*). Hydrilla has small sharp teeth on the edges of the leaves and spines or conical bumps on the undersides. Hydrilla also produces **tubers**; Brazilian elodea does not. American elodea has only 2-3 leaves per **whorl** and is smaller, usually less than 2.5 cm (1 in) long. These species also differ significantly in their flowers, with Brazilian elodea being the only one to produce large, attractive white flowers with three petals.

## Habitat

In its native range, Brazilian elodea lives in slow-moving and shallow waters. As an invader, it can be found in lakes, ponds, sluggish rivers, and streams. It grows best in enriched, somewhat acidic lakes, and prefers substrates of sand, mud, or stone.

## Spread

In the past, Brazilian elodea spread mostly due to release by aquarium owners and water gardeners. Since all plants in the United States are male, they can reproduce only **vegetatively** by plant fragments. Fragments can attach to recreational boats, trailers, and equipment and be spread to new water bodies. Once established, Brazilian elodea has the ability to cover 100 acres of water per year.

## Distribution

Brazilian elodea is native to South America, specifically Brazil and coastal regions of Argentina and Uruguay. It is found to be invasive in several states in the U.S., including all states in the Mid-Atlantic region.



## Environmental Impacts

Brazilian elodea grows rapidly—up to 30 cm (11.8 in) in length per day in ideal conditions.

It forms mats at the water's surface, which crowd out native species, impede aquatic recreational activities such as boating and fishing, destroy water quality, and make poor habitat for fish. Fragmented pieces can also clog water intake pipes.

United States Distribution



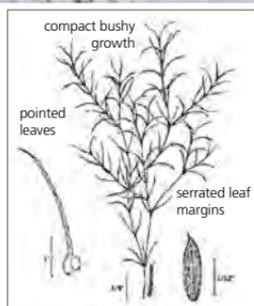
# Brittle Naiad

*Najas minor*



## Species at a Glance

Brittle naiad, also called brittle water nymph, is a **submerged** aquatic herb native to Europe and Asia. It gets its name from its fragile stems that can easily break into small pieces and cling to boats, equipment, and waterfowl and be moved to new locations.



## Identification

**Leaves:** Dark green leaves are pointed, **oppositely**-paired, and become stiff and recurved as they age. Growth appears compact and bushy. The leaves measure about 1 mm (0.04 in) wide and 0.5-3.5 cm (0.2-1.25 in) long. The leaf **margins** are **serrated** with 7-15 small but conspicuous teeth along each side. The base is **truncate** or lobed with fine teeth on the upper **margin**.

**Flowers:** Small, inconspicuous flowers grow in the leaf **axils** in late spring and early summer.

**Fruit/Seeds:** Single-seeded **fruits** mature throughout summer and late fall. They are 1.5-3.0 mm (0.06-0.1 in) long and are slightly curved with rectangular-shaped **areolae** arranged in longitudinal rows.

**Stems/Roots:** Slender stems may reach up to 2.5 m (8 ft) long and are profusely branched near the **apex**.



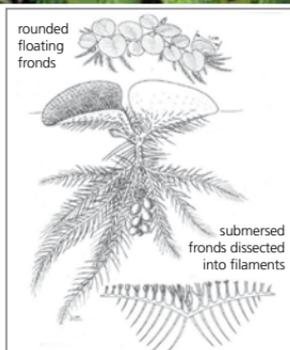
# Common Salvinia

*Salvinia minima*



## Species at a Glance

Common salvinia, also called “water spangles,” is a small free-floating aquatic fern native to tropical America. It was cultivated in the United States for use in ornamental fish tanks and ponds, but escaped to invade a variety of aquatic habitats. Once introduced, it has the potential to completely cover waterways.



## Identification

**Leaves:** Because it is a fern, leaves are referred to as **fronds**. **Fron**ds are borne in threes with two floating **fronds** and a third **submersed frond** that is dissected into filaments. The paired floating **fronds** are rounded with heart-shaped bases and notched tips. Smaller **fronds** lie flat on the water’s surface, while larger **fronds** fold at a distinct **mid-rib**, giving them a “cup-like” appearance. Length ranges from 0.4-2.0 cm (0.2-0.8 in). **Fron**ds grown in the shade remain broadly round and emerald green, while those grown in the sun become larger, and turn a rusty brown color. Floating **fronds** are covered with rows of white bristly hairs on top that branch out to create a water resistant shield. Long, chestnut colored hairs coat the underside of the floating **fronds**, **submersed** filaments, buds, and **rhizomes**.

**Flowers:** Salvinias are ferns and have no flower.

**Spores:** Spores are produced in **nut**-like sacs called **sporocarps** that are attached in spirals along the **submersed** filaments.

**Stems:** Horizontal branching **rhizomes** float just below the water’s surface and produce leaves at each **node**.

## Similar Species

Common salvinia may be confused with giant salvinia (*Salvinia molesta*), but it is the smaller of the two species and is readily distinguished by the morphology of the **frond** hairs. In both plants, the hairs are split four ways; however, in giant salvinia the hairs come together at the tip to form a distinct “egg-beater” structure. Typically, mature **fronds** of giant salvinia are quarter to half-dollar size, about twice the size of common salvinia.

## Habitat

While commonly found growing on the surface of still or slow-moving ponds, small lakes, canals, and slow streams, this species can also be found in shallow backwaters of bayous, oxbows, ditches, cypress swamps, and marshes inhabiting water bodies with salinity levels as high as 4-7 ppt.

## Spread

Common salvinia reproduces and spreads mostly by **fragmentation**. Any part of the **rhizome** that buds or breaks off can form into a new plant. These **rhizomes** can also lie dormant during periods of reduced moisture and cold and will sprout again when conditions are more favorable. While it does contain spores, these spores are thought to be sterile.

## Distribution

Native to Central and South America, Common salvinia first appeared in the United States in the St. John's River in eastern Florida where it is thought to have been introduced in the ballast water of transoceanic ships.

It quickly expanded its range westward and northward and can be found in the Mid-Atlantic region in New York, New Jersey, and Maryland.



## Environmental Impacts

The exponential growth of common salvinia allows it to quickly clog waterways and restrict recreational activities. It has been recorded growing as long as 12 m (39 ft), blanketing waterways with mats up to 25 cm (10 in) thick. These dense mats block sunlight from reaching native species and decrease oxygen concentrations that can ultimately impact fish and other aquatic species.

United States Distribution



# Creeping Water-primrose

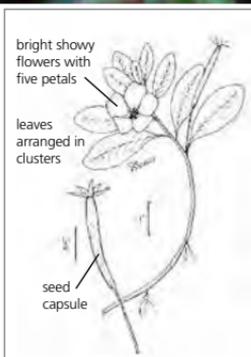
*Ludwigia peploides*



## Species at a Glance

Creeping water-primrose, also called floating primrose-willow, is a herbaceous, perennial, wetland plant whose sprawling stems usually grow flat along mud or a water surface.

Although native to parts of North America, this species has become invasive outside of its native range, including Washington State where it is listed as a Class A noxious weed because of its ability to form dense floating mats that can displace native aquatic plants and wetland grasses.



## Identification

**Leaves:** **Alternately** arranged leaves are clustered together and vary in size and shape from long and slender to round or egg shape. They are up to 9 cm (3.5 in) long. Leaf bases taper to a **stalk** that ranges from 2.5-4 cm (1-1.5 in) long. The leaves have smooth **margins** and are either hairless, or have long, soft hairs. The leaves are dark green with light green **pinnate** veins.

**Flowers:** Showy flowers have five bright yellow petals that are 1-1.5 cm (0.4-0.6 in) long and bloom late July to August. The flowers occur on long **stalks** arising from the leaf **axils**.

**Fruit/Seeds:** Capsules contain many small (1 mm) seeds.

**Stems/Roots:** Flowering stems are either floating or lying on the ground. Sprawling stems, which can reach a length of 2.7 m (9 ft), are fleshy, reddish in color, and either hairless or slightly hairy.

## Similar Species

Similar species include the marsh seedbox (*Ludwigia palustris*), which has flowers without petals; true forget-me-not (*Myosotis scorpiodes*), which has blue flowers and a distinct **midrib** with less apparent branching veins; and water smartweed (*Polygonum amphibium*), which has similar floating leaves to water-primrose, but the flowers are thick **spikes** of bright pink flowers.

## Habitat

This species grows along freshwater shorelines and sprawls across the water's surface. It typically inhabits still or slow-flowing freshwater habitats including the **margins** of wetlands, lakes, ponds, ditches, and streams in depths of up to 3 m (10 ft). It is very adaptable and can grow under a variety of nutrient, water quality, and substrate conditions. Its roots are able to absorb atmospheric oxygen, allowing it to survive in low oxygen waters, grow up on land, and tolerate dry periods.

## Spread

While it produces viable seeds, creeping water-primrose spreads mostly through **fragmentation**. Small pieces of stem can be spread to new areas by wind, water flow, or animals where it grows roots and develops into new plants.

## Distribution

Creeping water-primrose is native to South America, Central America, parts of the southern United States, and possibly Australia. In the United States, it is native from South Carolina to Kansas and south to Texas and Louisiana, but it is considered invasive in all Mid-Atlantic states.



## Environmental Impacts

Dense floating mats of creeping water-primrose can outcompete native plants and clog waterways, increasing the risk of flooding and affecting recreation, fishing, and navigation. This species also alters the chemistry of the aquatic environment, reducing dissolved oxygen levels by shading out **submerged** plants, impacting pH, phosphate, and nitrate levels, and making the habitat unsuitable for some native species.



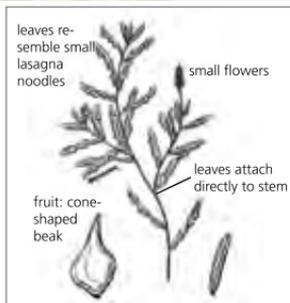
# Curly-leaf Pondweed

*Potamogeton crispus*



## Species at a Glance

Curly-leaf pondweed is an invasive aquatic perennial that can grow offshore in depths of up to 4.6 m (15 ft). It has a unique ability to form new plants under the ice in winter, making it one of the first nuisance plants to emerge in the spring.



## Identification

**Leaves:** **Submerged**, oblong, slightly translucent, leaves are olive-green to reddish-brown and have rounded tips, narrowing towards the base. They are **alternately** arranged and directly attached to the stem. They are 4-10 cm (1.6-4 in) long and 5-10 mm (0.2-0.4 in) wide with distinct wavy and finely toothed edges that resemble lasagna noodles.

**Flowers:** Small and tightly arranged flowers are located at the end of a slender, sometimes curved, **stalk** and appear above the water's surface from June through September.

**Fruit/Seeds:** Have a prominent cone-shaped beak and a bumpy crown-like ridge.

**Stems/Roots:** Slightly flat, reddish-brown stems grow from 0.3-0.9 m (1-3 ft) long and emerge from slender **rhizomes**, often branching as they grow giving it a bushy appearance.

## Similar Species

This species may be confused with other pondweeds, many of which have both **emergent** and **submerged** leaves. Curly-leaf pondweed has only **submerged** leaves. Other pondweeds also lack the tiny but visible serrations and wavy edges of the leaves.

## Habitat

Curly-leaf pondweed prefers soft substrates in shallow, alkaline, and high nutrient waters. It tolerates still or flowing water and is able to survive in low light conditions and water temperatures. It can grow in shaded, polluted, disturbed, or **turbid** waters where many native plants cannot.

## Spread

Burr-like winter buds called **turions** allow curly-leaf pondweed to regrow in new locations when they are moved around by natural water flow, recreational activities such as boating and fishing, and by intentional plantings for wildlife habitat. It can also reproduce and spread by seeds which are ingested by waterfowl and can pass through the digestive system unharmed.

## Distribution

Native to Eurasia, Africa, and Australia, curly-leaf pondweed was introduced into U.S. waters by hobbyists who used it as an aquarium plant. It has since spread to all states and is widespread throughout the Mid-Atlantic region.



## Environmental Impacts

Because of its tolerance for low light and temperature conditions, curly-leaf pondweed grows earlier than native plants in the spring. It forms dense surface mats that can impede recreational activities such as boating, swimming, and fishing. When it dies off in mid-summer, it may create anoxic conditions and increase nutrient content that can cause harmful algal blooms.

United States Distribution



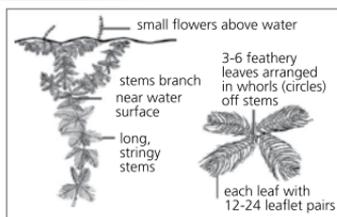
# Eurasian Watermilfoil

*Myriophyllum spicatum*



## Species at a Glance

Eurasian watermilfoil is a feathery, **submerged**, aquatic plant that was once commonly sold as an aquarium plant. Generally found in water less than 6.1 m (20 ft) deep, it quickly forms thick damaging mats that are causing harm in shallow areas of rivers and lakes throughout North America.



## Identification

**Leaves:** Feathery **whorls** of 3-6 leaves (four leaves per **whorl** is common) are openly spaced along the stem with 1-3 cm (0.3-1.2 in) between **nodes**. Leaves are threadlike, uniform in diameter, and have 12-24 **leaflet** pairs. They are aggregated into a **submersed terminal spike** and the tips often have a blunt, snipped-off appearance. Note that the occasional Eurasian watermilfoil leaf may have as few as five **leaflet** pairs. For this reason, it is always advised to count **leaflet** pairs on several leaves taken from various points along the stem.

**Flowers:** Tiny **whorls** of flowers are located on floral **bracts** atop slender **spikes** that rise above the water's surface. Flowers either have four petals or are without petals.

**Fruit/Seeds:** Hard segmented capsules contain four seeds.

**Stems/Roots:** Slender stems, which often curve to lie on top of the water's surface, begin to thicken before blooming and double their width further down.

## Similar Species

Without **fruits** or flowers, it can be difficult to distinguish Eurasian watermilfoil from the native northern milfoil (*Myriophyllum sibiricum*) and coontail (*Ceratophyllum demersum*). It may also be confused with other leafy milfoil species including bladderworts, hornworts, mermaid weeds, and water crowfoots, which generally have fewer than 14 **leaflet** pairs. Counting **leaflets** can provide helpful identification clues.

## Habitat

This extremely adaptable plant can thrive in a variety of conditions. It grows in a wide temperature range in still to flowing waters and even survives under ice. While Eurasian watermilfoil grows best in fertile, fine-textured sediments and nutrient-rich lakes with lots of sunlight, it will readily inhabit disturbed lake beds.

## Spread

Eurasian watermilfoil does not rely on seeds for reproduction but instead reproduces by **fragmentation**. Plant fragments break off and float via water currents, allowing it to disperse long distances and hitchhike on boats, boat trailers, motors, and fishing equipment.

## Distribution

Native to Europe, Asia, and northern Africa, Eurasian watermilfoil was first discovered in the eastern United States in the 1940s, but may have arrived as early as the late 1800s. It is now established in nearly every U.S. state and at least three Canadian provinces. It is common in lakes, ponds, and rivers all throughout the Mid-Atlantic region.



## Environmental Impacts

Eurasian watermilfoil forms thick mats that can interfere with swimming, fishing, waterfowl hunting, boating, and other recreational activities. Plant fragments can also become wrapped around boat propellers and other equipment. Fish and wildlife are impacted when Eurasian watermilfoil shades out nutrient-rich native plants that provide food, shelter, and spawning areas for other organisms. Heavy infestations can also clog industrial and power plant intakes and even reduce local property values.

United States Distribution



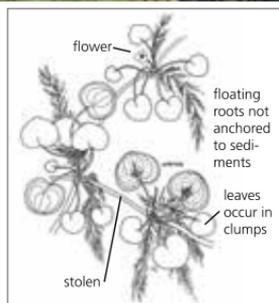
# European Frog-bit

*Hydrocharis morsus-ranae*



## Species at a Glance

European frog-bit is an herbaceous aquatic plant that resembles a miniature water lily. It has been found in the Great Lakes since the 1930s but is now spreading inland into streams and lakes within the basin.



## Identification

**Leaves:** Small, thick, heart-shaped, and leathery leaves are 1.5-6.5 cm (0.6-2.6 in) long and occur in clumps that are not anchored to the bottom sediment. They have smooth edges resembling those of a miniature water lily. A dark purplish-red spongy coating is present on the underside of the leaves, allowing it to float on the water's surface.

**Flowers:** Small, showy flowers are about 1 cm (0.4 in) in length and show up in early summer. Each flower has three white petals and a yellow center.

**Stems/Roots:** Stem-like extensions called **stolons** run from the center of the plant to produce juvenile plants. These **stolons** also produce **turions** that break free and sink to the bottom to lie dormant for the winter. Numerous free-floating, unbranched roots grow up to 30.5 cm (12 in) and form thick mats of tangled roots and **runners**.

## Similar Species

While it is often mistaken for species of water lily, European frog-bit leaves are distinctly heart-shaped, leathery, and usually smaller. Water lily flowers are much larger with more than three petals. It may also be confused with American frog-bit, little floating heart, spatterdock, and watershield.

## Habitat

European frog-bit prefers quiet, still, calcium-rich areas such as marshes, fens, swamps, backwaters, bays, sheltered coves, slow-moving shorelines of rivers, streams, and lakes, and poorly drained ditches.

## Spread

European frog-bit can spread to new areas by plant fragments or by **turions**, which float to the surface and begin to grow in the spring. A single plant can produce 100 to 150 **turions** in one season. It can also hitchhike on boats, trailers, waterfowl, and flowing currents, and may also be spread deliberately by humans that purchase it as an aquarium or water garden plant.

## Distribution

Native to Europe and northern Asia, European frog-bit was introduced intentionally in the United States as a commercial ornamental species. It escaped cultivation and spread to the Canadian shorelines of Lake Erie, Lake Ontario, the St. Lawrence River in New York, and Lake Champlain in Vermont. Populations are also present in Pennsylvania, New Jersey, Michigan, and Washington.



## Environmental Impacts

European frog-bit populations increase rapidly, forming dense mats that decrease the amount of nutrients, dissolved oxygen, and light penetration into the water and limiting the growth of any native vegetation beneath. These mats can also inhibit the movement of waterfowl and fish, and limit recreational activities; however, it can serve as a food source for some species of water birds, fish, and insects.

United States Distribution



# European Water Clover

*Marsilea quadrifolia*



## Species at a Glance

European water clover, also called European water fern or water shamrock, is a perennial herbaceous fern that gets its name from its clover-shaped leaves. It poses a threat to ecosystems as dense stands form and crowd out native wetland plants.



## Identification

**Leaves:** Leaves are divided into four triangle-shaped **leaflets** that are hairless and approximately 0.6-2.5 cm (0.25-1 in) long. They are either slightly **submerged**, floating, or **emergent**. Both the upper and lower surfaces of the **leaflets** are pale green or bluish-green. The upper **leaflet** surface is smooth while the lower surface may have short fine hairs. **Emergent leaflets** may fold together at night and spread outward during the day.

**Flowers:** This species is a fern and has no flower.

**Stems/Roots:** Thin **petioles** are typically 5-10 cm (2-4 in) long and form from **creeping rhizomes**. They are straw-colored to light green, circular in cross section, and are usually smooth. **Submerged petioles** often curve upward, while **emergent petioles** have a tendency to lean or sprawl.

**Spores:** Near the base of the **petioles** are small spore-bearing bodies called **sporocarps**. They are .35-.5 cm (0.1-0.2 in) long, oval, thick, reddish-brown, dark brown, or dark purple in color, and somewhat flattened in shape. They are typically arranged in groups of 2-3, although there can be anywhere from 1-5. Young **sporocarps** are hairy but become smooth as they age.

## Similar Species

European water clover may resemble species of wood sorrel (*Oxalis*) or clover (*Trifolium*), but it is a spore-producing fern rather than a flowering seed plant. Wood sorrel and clover can be distinguished by their **trifoliate** leaves and terrestrial habits, while European water clover has **quadrifoliate** leaves and is primarily aquatic.

## Habitat

Although this species is capable of growing on wet ground, it is typically found growing in shallow and slow-moving waters of lakes, ponds, and creeks.

## Spread

European water clover is a popular water garden plant, giving it the potential to spread into natural areas through intentional release or accidental escapes. Once introduced, it can easily spread by **rhizomes** and **sporocarps** that can float downstream on water currents or be moved to new locations on boats, trailers, or on waterfowl. The **sporocarps** can remain dormant for decades until conditions are favorable to release the spores.

## Distribution

Native to parts of southeastern Europe and Asia, this species was introduced into North America during the 19th century as an ornamental plant. Currently, this fern can be found in several northeastern and Midwestern states, including New York, Pennsylvania, New Jersey, Delaware, Maryland, and North Carolina.



## Environmental Impacts

While ecological threats of the European water clover are somewhat unknown, this species is capable of forming **monotypic** stands that can outcompete native aquatic plants for available sunlight and habitat. These stands can also persist during the winter seasons because of the underground **rhizomes**.

United States Distribution



# European Water-starwort

*Callitriche stagnalis*



## Species at a Glance

European water-starwort, also known as common or pond water-starwort is a small, delicate, aquatic perennial herb that roots to the substrate in shallow water. The appearance of this species can vary slightly depending on its habitat and growing conditions.

## Identification

**Leaves:** **Opposite** leaves are arranged in pairs along the stem and are both floating and **submerged**. Floating leaves are oval-shaped, have 5-7 veins, and are up to 2 cm (0.8 in) long. **Submerged** leaves are typically narrow and linear, have a single vein, and grow 4-10 mm (0.2-0.4 in) in length; however, they can also be broader and more closely resemble the floating leaves.

**Flowers:** Tiny, simple flowers don't have **sepals** or petals and are typically located right next to one another in the leaf **axils**. The flowers can have 0-4 (but usually two) small, white **bracts** at their bases, which may help the flowers float on the water and aid in pollination.

**Fruit/Seeds:** Rounded **fruits** are 1.5-2 mm (0.06-0.08 in) thick with a thin wing extending from the base to the head of the **fruit**. Four compartments, each containing one seed, do not split when ripe.

**Stems/Roots:** Elongate and branched stems can grow from 10-30 cm (4-12 in) in length, rising or sprawling to the surface.



## Similar Species

May be confused with other water-starworts (*Callitriche spp.*); however, the mature **fruits** of other species are not round in shape and lack the distinctive wing on the **fruits**. Due to the variability in leaf shape and size, mature **fruit** must be examined for positive identification of all water-starworts. European water-starwort may also be confused with other **opposite**-leaved delicate plants when not in **fruit**, such as mudwort (*Elatine sp.*) or horned pondweed (*Zannichellia palustris*).

## Habitat

This species is typically found in shallow waters of lakes, ponds, rivers and streams. It can tolerate some salinity such as brackish waters or salt marshes and flats.

## Spread

European water-starwort was first recorded in New York in 1861, most likely brought over in the ballast water of ships. Once introduced, it became a popular aquarium plant and subsequent escapes and releases have contributed to its spread throughout North America. It spreads through both seeds and plant fragments. Seeds can pass through the digestive tracts of birds and be released in new locations, and plant fragments and stems can easily attach to boats, trailers, and other aquatic recreational equipment.

## Distribution

Introduced from Europe and North Africa, this species is found in the Pacific Northwest, in the Mid-Atlantic region, and has scattered populations in Tennessee, Alabama, Montana, and Wisconsin.



## Environmental Impacts

European water-starwort is capable of forming dense mats of vegetation that may crowd out and displace native aquatic vegetation.



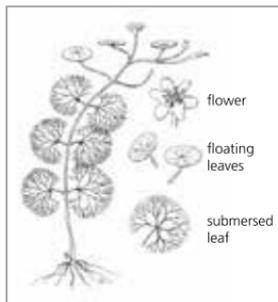
# Fanwort

*Cabomba caroliniana*



## Species at a Glance

Fanwort is a **submersed** freshwater perennial that can be found rooted in the substrate or floating on top of the water. When rooted, stems may reach lengths of up to 6m (20 ft). It is persistent, aggressive, and competitive, bringing with it the potential to take over aquatic ecosystems.



## Identification

**Leaves:** Two types of leaves include **submersed** and floating.

**Submersed** leaves are delicate, fan-shaped, and usually green in color, averaging 5 cm (2 in) in diameter. They are finely divided and arranged in **opposite** pairs along the stem. Floating leaves, which are not always present, are small and narrow (less than 1.3 cm [0.5 in]), oval to diamond in shape, and arranged in an **alternating** pattern.

**Flowers:** Small white, pink, or purple flowers with a diameter less than 1.3 cm (0.5 in) grow from the tips of the stems and float on the water's surface.

**Stems/Roots:** Range from grass to olive-green and sometimes reddish-brown. Shoots are upturned extensions of the horizontal **rhizomes** and may reach lengths of up to 6m (20 ft).

## Similar Species

Fanwort is often confused with other leafy milfoils, Beck's water-marigold (*Megalodonta beckii*), some bladderworts, hornworts, mermaid weeds, and water crowfoots. The leaves of watermilfoils are **whorled** and it has small flowers growing from where the leaves meet the stem. Beck's water-marigold has yellow **composite flowers** and **sessile** leaves, while fanwort has white flowers and slender leaves. Water marigold also has **opposite** leaves that attach directly to the stem with no **petiole** between the leaf and stem.

## Habitat

This very hardy plant is usually found rooted in muddy areas of slow moving waters such as streams, small rivers, lakes, and ponds. It can establish in a wide variety of environments and tolerate a wide range of temperatures, allowing it to overwinter in frozen lakes.

## Spread

Fanwort is thought to have spread from intentional and unintentional release in the aquarium trade. Its fragile stems break off easily and most pieces can re-sprout and grow into new plants.

## Distribution

Native to the sub-tropic areas of South America and Gulf of Mexico region of the United States, fanwort has been introduced to the Northeast and the Pacific Northwest. It can be found in scattered populations all throughout the Mid-Atlantic states except for West Virginia.



## Environmental Impacts

Fanwort is highly competitive and persistent, forming dense mats at the water's surface that block sunlight into the water column, negatively impacting native plant species, biodiversity, and water quality. It can also clog waterways, impacting recreational activities such as boating, fishing, and swimming.



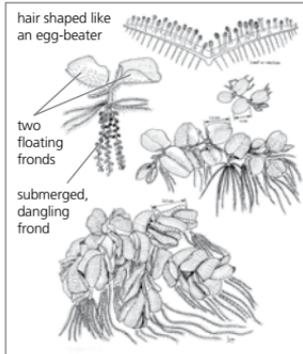
# Giant Salvinia

*Salvinia molesta*



## Species at a Glance

Giant salvinia, also known as water fern and kariba-weed, is a floating fern native to southern Brazil. This species is capable of very high growth rates depending on its habitat conditions, potentially doubling in volume every 7-10 days and quickly forming dense mats on the surface of the water.



## Identification

**Leaves:** Because it's a fern, leaves are referred to as **fronds**. Two floating **fronds** appear at each **node** of the stem with a third **frond** that dangles under the water. Floating **fronds** are oval, folded, green, about 2 cm (0.8 in) long, and are covered in 4-pronged hairs on the upper surface that join at their tips to resemble an egg-beater. The purpose of these hairs is to repel water and provide buoyancy. In the early stages of life, the **fronds** will lie flat on the water's surface, but as they age they fold up and compress into chains. The underwater **frond** is brown, highly divided, and is sometimes mistaken for a root; however, the plant has no true roots. It also acts to conceal the spores.

**Flowers:** Salvinias have no flowers.

**Spores:** Round, **nut-like sporocarps** trail beneath the plant and produce infertile spores.

**Stems/Roots:** A horizontal **rhizome**, which lies just below the water's surface, ranges from grass to olive-green and sometimes reddish-brown. Shoots are upturned extensions of the horizontal **rhizomes** and may reach lengths of up to 6m (20 ft).

## Similar Species

Often confused with common salvinia (*Salvinia minima*), this species is the larger of the two, and can be distinguished by the hairs on the **fronds** that form the distinct “egg-beater” structure.

## Habitat

Giant salvinia thrives in slow-moving, nutrient-rich, warm, fresh waters such as ditches, ponds, lakes, slow rivers, and canals. It will only tolerate freshwater and cannot grow in brackish or marine environments. While it can withstand freezing air temperatures, it will not survive under ice.

## Spread

Giant salvinia was most likely introduced by intentional and unintentional releases due to its use in aquariums and water gardens. Once introduced, it can spread by vegetative fragments that hitchhike on recreational boats and equipment and on the feathers or fur of waterfowl and animals. Each small plant fragment is capable of growing into a new plant. In addition, each **node** has several lateral buds, which can remain dormant through times of stress and drought until conditions are right for growth.

## Distribution

Native to southeastern Brazil and northern Argentina, giant salvinia was introduced as an ornamental aquatic plant and was first found in the United States in South Carolina in 1995. It is now scattered throughout the southern U.S. from California to Virginia.



## Environmental Impacts

Giant salvinia forms dense mats of vegetation that reduce water flow and lower the light and oxygen conditions in the water. This stagnant dark environment shades out native plants and creates bare spots in the habitat below, altering the diversity and quality of the ecosystem. Invasions of this species also threaten socio-economic activities dependent on open flowing water such as hydro-electricity generation and fishing and boating transport.



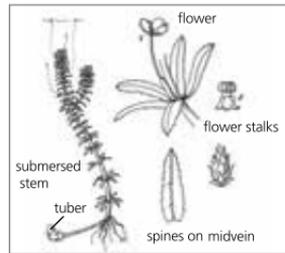
# Hydrilla

*Hydrilla verticillata*



## Species at a Glance

Hydrilla is a **submerged** aquatic perennial that many consider nature's "perfect weed." It comes in two forms: **dioecious** and **monoecious**. Both forms grow and spread at a very fast rate, covering the surface of water bodies and restricting boating, fishing, swimming, and other recreational uses.



## Identification

**Leaves:** While morphological characteristics can vary, leaves are typically strap-like and pointed with small sharp teeth on the edges that are difficult to see with the naked eye. Spines or conical bumps are sometimes found on the **midrib** on the underside of the leaf; however, these are not always present. The underside of the **midrib** can also be red. Leaves are generally 2-4 mm (0.08-0.2 in) wide, 6-20 mm (0.2-0.8 in) long, and occur in **whorls** of 3-8.

**Flowers:** Small (10-50 mm [0.4-2 in] long) white flowers float on the water's surface, are attached at the leaf **axils**, and are clustered towards the tips of the stems.

**Stems/Roots:** Long branching stems form intertwined mats at the water's surface. Plants are usually rooted to the lake bottom, growing upward from the substrate in water up to 3.7 m (12 ft) deep. During the late growing season, small white **tubers**, which are used for food storage, are formed on the plant's roots, allowing it to overwinter.

## Similar Species

Hydrilla closely resembles Brazilian elodea (*Egeria densa*) and North American elodea (*Elodea canadensis*). Brazilian elodea typically has **whorls** of 3-6 leaves, is usually 2-3 cm (0.8-1.2 in) long, and has tiny teeth on the **margins** with no conical bumps on the **midrib** below. The native North American elodea has leaves that occur in **whorls** of three and is usually a much smaller plant. Neither species of elodea produces the **tubers** or **turions** found on Hydrilla.

## Habitat

Hydrilla grows in a wide variety of still and flowing waters including freshwater lakes, ponds, rivers, impoundments, and canals. It tolerates a wide range of pH, nutrient, and light levels and is somewhat winter-hardy, but optimum temperature for growth is 20-27°C (68-81°F).

## Spread

Because Hydrilla reproduces primarily **vegetatively**, even the smallest living plant fragment can float downstream and form a new plant. While it was imported to the United States as an aquarium plant, recreational activities now help it spread.

## Distribution

While it is unknown where Hydrilla originated, possible native ranges include Asia, Africa, and Australia. It continues to spread and is listed as a federal noxious weed in the United States. While the **dioecious** form appears to spread from South Carolina south, the **monoecious** form is spreading both north and south and is typically the form found north of North Carolina and in all the Mid-Atlantic states.



## Environmental Impacts

Hydrilla's dense thick mats interfere with commercial activities by clogging water intake pipes and filters and hindering irrigation. It also restricts recreational uses and prevents sunlight from reaching other species growing beneath it. As the mats die and decay, bacteria deplete oxygen from the water, impacting fish and other aquatic organisms.



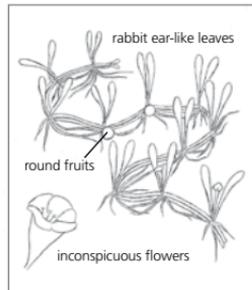
# Mudmat

*Glossostigma cleistanthum*



## Species at a Glance

Mudmat is a low-growing, mat-forming, aquatic invasive plant that has remained largely under the radar due to its small size and the public's lack of familiarity with it. The plant itself is usually less than 2 cm (0.8 in) high and can be found **submerged** in the water or emerging above the water's surface.



## Identification

**Leaves:** Bright green paired leaves resemble tiny rabbit ears. They are narrow, about 1- 4 cm (0.4-1.6 in) in length, and are slightly expanded at the tip. They taper to the base and may be **sessile** or **stalked**. Leaf margins are smooth.

**Flowers:** Small 1-3 mm (0.04-0.1 in) wide flowers are inconspicuous in the leaf **axils** at the base of the plant. They emerge when the water recedes in the summer months. Color ranges from mauve, lilac, pink, blue, and bluish-white to white. Closed, self- fertilizing flowers called **cleistogams** are also produced underwater in the soil among the roots.

**Fruits:** Round, thin-walled capsules are divided into two cavities that contain many small dark brown seeds.

**Stems/Roots:** Creep horizontally just below the soil surface and root along the **nodes**.

## Similar Species

Native mudwort species (*Limosella* spp.) closely resemble mudmat. It may also be confused with **emergent** leaf forms of some members of the bladderworts (*Utricularia* spp.).

## Habitat

Mudmat prefers conditions with low pH, conductivity, and phosphorous in shallow waters, swamps, and periodically flooded areas with little wave action.

## Spread

Initial introduction of mudmat probably occurred by aquarium release and its subsequent spread may have been mediated by both human activities, such as recreational boating, and by natural means, such as hitchhiking on migrating geese or other waterfowl.

## Distribution

Native to Australia, New Zealand, India, and east Africa, mudmat was discovered in the United States in 1992 at a single location in southern Connecticut. In the Mid-Atlantic, it can be found in areas of Pennsylvania, New Jersey, Delaware, and Maryland.



## Environmental Impacts

Mudmat forms thick carpet-like mats that smother the lake bottom from the shoreline to depths of greater than 2 m (6.6 ft). It spreads very rapidly, covering prime shoreline habitat, reducing biodiversity, and threatening native plant and animal communities.

United States Distribution



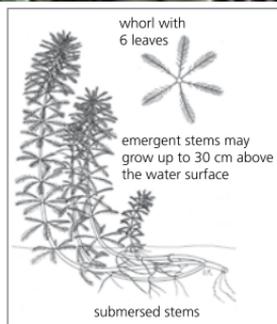
# Parrot Feather

*Myriophyllum aquaticum*



## Species at a Glance

Parrot feather, also called Brazilian watermilfoil, is an herbaceous aquatic perennial and member of the watermilfoil family. It gets its name from its bright green feather-like leaves which are **whorled** around the stem and form thick suffocating mats. Only female parrot feather plants have been found in North America.



## Identification

**Leaves:** **Emergent** leaves are robust, vibrant green, feathery, and covered with a waxy coating. They are arranged around the stem in **whorls** of 4-6 and are 2.5-5 cm (1-2 in) long with 10-18 **leaflet** pairs. Leaves become more closely arranged toward the growing tips of the plant. Limp **submerged** leaves are brownish to reddish, often appearing deteriorated. They are 1.5-3.5 cm (0.6-1.4 in) long with 20-30 divisions per leaf.

**Flowers:** Small (1.5 mm [0.06 in]) white-pinkish flowers appear between the leaf **axils** of female plants in the spring.

**Stems/Roots:** Long unbranched stems reach heights of 30 cm (12 in) above the water's surface. When attached to a bank, they can extend out several yards over the water's surface.

## Similar Species

A close relative, Eurasian watermilfoil (*Myriophyllum spicatum*) is easily mistaken for the **submerged** leaves of parrot feather. Other look-a-likes include bladderworts, hornworts, mermaid weeds, water crowfoots, and other leafy milfoils. The **emergent** stems and leaves are the most distinct characteristics of parrot feather, as they can grow up to 30 cm (12 in) above the water surface and resemble small fir trees.

## Habitat

Parrot feather is hardy but prefers shallow, nutrient-rich, and slow-moving waters. It is most common in shallow water as a rooted plant but can also be found as a floating plant in deeper nutrient-enriched lakes.

## Spread

Since all parrot feather plants in the United States are female, they spread exclusively by **fragmentation**. Therefore, human activities such as water gardening, boating, and fishing, can easily spread fragments to new locations where they can grow into new plants.

## Distribution

Native to South America in the Amazon River, parrot feather was introduced as a garden plant in the 1800s. It has since spread throughout the United States and can be found in all Mid-Atlantic states.



Tiny white flowers appear between leaf axils of emergent stems

## Environmental Impacts

Parrot feather forms thick mats that can shade out native plant and algae species, impact water flow, clog recreational waterways and irrigation canals, and alter the physical and chemical characteristics of lakes and streams.



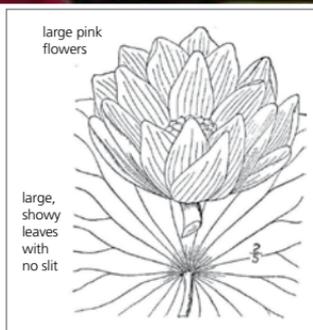
# Pink Lotus

*Nelumbo nucifera*



## Species at a Glance

Pink lotus, also called sacred lotus and Asian lotus, is a showy aquatic perennial that resembles a water lily, although the two are not related. It is considered invasive outside of its native range due to the dense colonies it can produce in natural areas.



## Identification

**Leaves:** Medium green to blue-green leaves either float at the surface of the water or are held up to 1.5 m (5 ft) above the water by their **petioles**. Circular leaf blades are hairless with smooth edges that may undulate up and down. Leaves are large, showy, and water resistant, spanning 0.2-0.9 m (0.5 to 3 ft) across with many radiating veins.

**Flowers:** Large, fragrant flowers are held up to 2 m (6 ft) above the water. They have 12-15 pink petals with showy yellow **stamens** around a central large **receptacle**. Flowers are 10-25 cm (4-10 in) across. The blooming period occurs during the summer and can last about two months. The short-lived flowers open up in the morning and begin to lose their petals by the afternoon.

**Fruit/Seeds:** After the flowers drop, a seed pod remains in the center of the flower with many small openings that resemble a shower head. These pods turn from green to dark brown in color. Individual seeds form in the pod and may remain viable for centuries.

**Stems/Roots:** Thick **rhizomes** have fibrous roots and allow the plant to aggressively re-grow new plants.

## Similar Species

Pink lotus is very similar to the native American lotus (*Nelumbo lutea*); however, it can be distinguished by the color of the flowers. American lotus has yellow flowers instead of the characteristic pink; however, cultivars of these two species tend to have whitish-pink flowers. The leaves of the pink lotus also lack the characteristic slits found on water lily leaves.

## Habitat

Pink lotus prefers full sun and water up to 2 m (6 ft) deep in mucky submerged soils with little exposure to wind and waves. It thrives in small ponds, lagoons, marshes, and shallow areas of lakes and rivers.

## Spread

Colonies of pink lotus can spread aggressively by both seeds and **rhizomes**, giving them the capability to rapidly establish and spread throughout water bodies.

## Distribution

Native to southern and eastern Asia, pink lotus is the national flower of India and Vietnam, and has multiple medicinal and culinary uses. It was most likely introduced into the United States as an ornamental, which escaped cultivation and established into natural areas. It can be found in multiple states in the midwestern and eastern United States, including New York, New Jersey, Maryland, West Virginia and North Carolina in the Mid-Atlantic region.



## Environmental Impacts

Dense mats of floating pink lotus can inhibit the growth of other native aquatic vegetation, decreasing biodiversity and impacting the wildlife that depend on native plants for food and shelter. In addition, these floating mats can negatively impact recreational activities like boating, angling, and swimming.



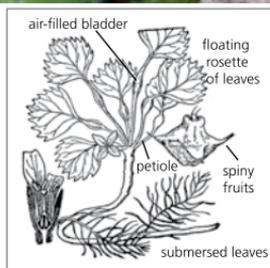
# Water Chestnut

*Trapa natans*



## Species at a Glance

Water chestnut is a rooted aquatic plant very different from the one you find in Chinese take-out. It can dominate ponds, shallow lakes, and rivers because it grows in thick, dense colonies and can grow as much as 4.8 m (16 ft) in length.



## Identification

**Leaves:** Come in two distinct forms: floating and **submersed**. Floating leaves are triangular or fan-shaped with noticeably toothed **margins** on the outer edges. They are roughly 1-3 cm (0.4-1.2 in) long and are arranged in large floating **rosettes**. The upper leaf surface is glossy, while the underside is covered with soft hairs. These leaves are kept afloat by spongy, inflated bladders attached to long stems called **petioles** (up to 15 cm [5.9 in] long), which connect the leaves to the **submersed** section of the plant. The **submersed** leaves are green and feathery, and **whorl** around the cord-like stem.

**Flowers:** Small flowers are about 1 cm (0.4 in) long with four white petals located in the center of the leafy **rosette**, and usually appear in mid-to-late July.

**Fruit/Seeds:** Black **nut**-like structures have four spiny projections that are so sharp they are capable of penetrating shoe leather.

**Stems/Roots:** Numerous finely branched roots develop along the lower stem, which assist in anchoring the plant to the substrate.

## Similar Species

None.

## Habitat

Water chestnut can grow in any freshwater setting, but prefers nutrient rich waters less than 4.8 m (16 ft) deep in ponds, lakes, slow-moving streams, and rivers.

## Spread

Water chestnut has a high reproductive rate, with each plant producing up to 15 **nuts** per season. Each **nut** can sink to the bottom and remain viable for up to 12 years. It can also spread **vegetatively** when the **rosettes** of floating leaves break apart and fragments attach to boats and trailers or float to new locations.

## Distribution

The native range of water chestnut includes Europe, Asia, and Africa. It was brought to the United States by water gardeners in the 1800s and quickly established, with the first known occurrence in Massachusetts. In the Mid-Atlantic, it has spread to the waters of Delaware, Maryland, New Jersey, New York, Pennsylvania, Virginia, Washington DC, and West Virginia.



## Environmental Impacts

The dense floating mats of water chestnut can choke a water body, limiting light and oxygen and impeding boating and other recreational activities. Colonies of this plant can outcompete native organisms for nutrients and space, while offering little nutritional value for wildlife.

United States Distribution



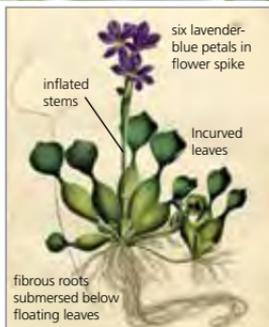
# Water Hyacinth

*Eichhornia crassipes*



## Species at a Glance

Water hyacinth is a free-floating flowering perennial that forms dense “rafts” of plant material in the water that can cover a lake surface from shore to shore. Its beauty makes it a popular ornamental plant for ponds; however, its fast growth makes it one of the worst aquatic weeds in the world, as it can double its population in as little as six days.



## Identification

**Leaves:** Oval, rounded, circular, or elliptical leaves are arranged in **rosettes** on **stalks** that can rise 0.9 m (3 ft) above the water's surface. They are thick, glossy, waxy green, waterproof, and typically up to 15 cm (6 in) wide. The sides are gently incurved and often undulate, and leaf bases are heart-shaped, square, or rounded with dense veins.

**Flowers:** Multiple flowers (8-15) form in a single showy **spike** that can be up to 30 cm (12 in) long atop a thick **stalk**. Each flower in the **spike** has six lavender-blue petals. The uppermost petal is somewhat larger with a bright yellow, blue-bordered, central spot.

**Fruit/Seeds:** A three-celled capsule contains many seeds.

**Stems/Roots:** Spongy, inflated stems can grow up to 0.5 m (1.5 ft) long. The stems are filled with air spaces, which gives them a spongy appearance and allow them to stay afloat. Fibrous roots hang **submersed** beneath the floating leaves. They are dark purple to black and have a feathery appearance.

## Similar Species

Water hyacinth can be confused with American spongeplant (*Limnobium spongia*) because of its similar looking leaves; however, American spongeplant has white roots instead of black and has slender, ridged stems instead of bulbous, inflated stems. It can also be confused with water lettuce (*Pistia stratiotes*), which has large ribbed leaves and doesn't have the showy flowers characteristic of water hyacinth.

## Habitat

This species grows in shallow temporary ponds, wetlands, marshes, sluggish flowing waters, lakes, reservoirs, rivers, and ditches of temperate climates. It can tolerate extremes in water level fluctuations and seasonal variations in nutrients, pH, temperatures, and toxins. It is not winter hardy and needs temperatures above 12°C (54°F) to survive.

## Spread

Because of its attractive purple flowers, water hyacinth is a popular plant among ornamental pond and water garden enthusiasts. As a result, escape from water gardens as well as deliberate releases have been major modes of dispersal. Once introduced, its high growth rate has allowed it to quickly establish and spread. It reproduces both by **fragmentation** and by forming plantlets at the end of a shoot that grows from the base of the stem.

## Distribution

Native to South America in Brazil, water hyacinth is now found in more than 50 countries on five continents. It is believed to have been introduced to the United States in 1884 for the Cotton States Exposition held in New Orleans. Because of its beauty, it was given as gifts to attendees who took it home to add to backyard ponds. By 1900 it had escaped cultivation to become a serious pest. In the Mid-Atlantic, this species is found in New Jersey, New York, Delaware, Virginia, North Carolina, and South Carolina.



## Environmental Impacts

Water hyacinth forms thick mats that block waterways and limit boat traffic, swimming, fishing, and other recreational activities. In drainage and irrigation canals, it impedes flow which can result in flooding and clogged pumps. Dense mats prevent sunlight and oxygen from reaching the water column and the **submerged** plants below, shading out native species and reducing biodiversity.



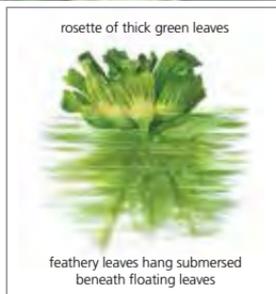
# Water Lettuce

*Pistia stratiotes*



## Species at a Glance

As its name implies, water lettuce is a floating perennial plant that resembles an open head of lettuce. It forms in colonies of **rosettes** that link together to blanket the water's surface, blocking waterways and disrupting natural ecosystems.



## Identification

**Leaves:** Thick, soft, light green leaves are formed in **rosettes** with no leaf stems. **Rosettes** can occur by themselves or connected to others by short **stolons**. Leaves are large, up to 16 cm (6 in) long with parallel ridges (veins) covered in short hairs. Leaf **margins** are wavy and the top **margins** are scalloped.

**Flowers:** Flowers are inconspicuous and hidden in clusters in the center amongst the leaves. They form on a small **stalk** with a single female flower and a **whorl** of male flowers above.

**Fruit/Seeds:** The **fruit** arises from the female flower as a many-seeded green berry.

**Stems/Roots:** Roots are light-colored and feathery and hang **submersed** beneath the floating leaves.

## Similar Species

Water lettuce may be confused with water hyacinth (*Eichhornia crassipes*); however, water lettuce has large ribbed leaves and it doesn't have the showy flowers characteristic of water hyacinth.

## Habitat

Mostly occurring in slightly acidic lakes, rivers, ponds, and canals in temperate climates, water lettuce has also been found to survive in mud. It is not winter hardy, requiring temperatures above 15°C (59°F) for growth.

## Spread

While some believe water lettuce is a native species, others believe it was brought over in the ballast water of ships from the tropical and subtropical regions of Asia, Africa, and South America. It is also commonly sold through the aquarium industry and additional introductions have occurred as plants are intentionally released or escape from ponds and water gardens. This plant can spread by **fragmentation**, by daughter plants that form on the **stolons** of the mother plant, or by seeds.

## Distribution

Water lettuce has been present in Florida since as early as 1765; however, it has since spread throughout the southeastern United States north to New York and westward to Texas, Arizona, and California. It is also present in Hawaii. In the Mid-Atlantic, water lettuce is found in Delaware, New Jersey, New York, North Carolina, and Maryland.



## Environmental Impacts

The large mats formed by water lettuce negatively impact boating, fishing, and swimming. They also make navigation difficult, hinder flood control efforts, and clog hydroelectric turbines. The colonies of **rosettes** decrease biodiversity by blocking sunlight and oxygen from penetrating into the water column, thereby altering the native plant and animal communities below.

United States Distribution



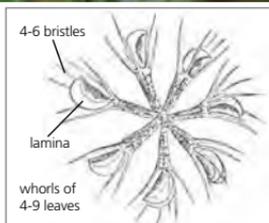
# Waterwheel

*Aldrovanda vesiculosa*



## Species at a Glance

Waterwheel is a free-floating, rootless, aquatic plant that gets its name from its unique leaves that are **whorled** around the stem, resembling a wheel. It is carnivorous, behaving like a Venus flytrap and using a trap-like structure called a **lamina**. The **lamina** can snap shut in 0.01 seconds, which is the fastest recorded plant movement in the world.



## Identification

**Leaves:** **Whorls** consist of 4-9 leaves arranged around a free-floating stem, giving the plant a cylindrical appearance. The leaves are up to 23 mm (2.3 cm) in diameter. The clam-like traps, called **lamina**, are 2-3 mm (0.2-0.3 cm) long and are held by **petioles** at the end of the leaves. The **lamina** appears as two lobes of translucent tissue that is studded inside with 4-6 bristles. The bristles protect the trap from being triggered by non-food items like floating debris. Trap lobes contain 30-40 trigger hairs which, when stimulated, cause the trap to snap shut.

**Flowers:** Tiny flowers with five green **sepals** and five white petals bloom in the summer. They are only open for 2-3 hours, usually during high sun, after which they are brought beneath the water for seed production.

**Fruit/Seeds:** Flowering is sporadic and not very successful, yielding only 1-10 seeds per **fruit**. In the fall, the plant forms **turions** that sink to the bottom and over-winter.

**Stems/Roots:** Simple or sparsely-branched stems are filled with air to aid in flotation. Stem length varies between 6 cm (2.5 in) and 20 cm (8 in).

## Similar Species

Waterwheel may be confused with other carnivorous plants like species of bladderworts (*Utricularia spp.*), as well as Hydrilla (*Hydrilla verticillata*), naiads (*Najas spp.*) and watermilfoils (*Myriophyllum spp.*) However, waterwheel is the only plant with the distinguishing clam-like **lamina**.

## Habitat

Found in wetlands, streams and lake littoral zones, water wheel prefers clean, shallow, warm standing water with bright light, low nutrient levels, and a slightly acidic pH. Under ideal conditions it is capable of extremely rapid growth; however, it does not tolerate degraded habitats or large fluctuations in water chemistry.

## Spread

Waterwheel spreads mainly through the movement of stem fragments and **turions** that can be transported by recreational equipment like boats, and fishing gear, as well as by waterfowl that can move them between habitats. This plant is also available for sale through the aquarium and water garden industry, and can be accidentally or intentionally released.

## Distribution

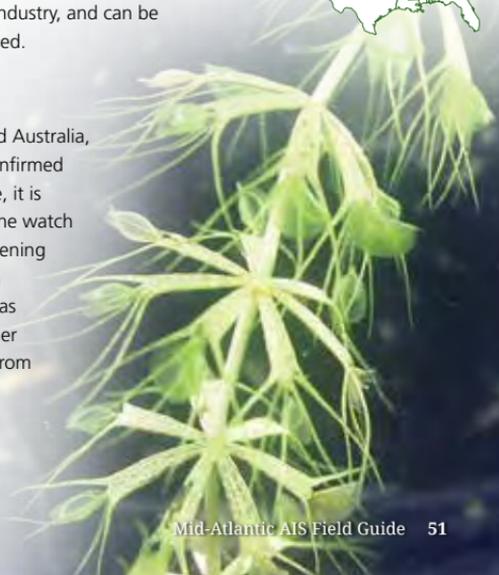
Native to Europe, Africa, Asia, and Australia, waterwheel has only about 50 confirmed populations worldwide. Therefore, it is considered rare, but remains on the watch list because it may become threatening to native communities. In 2012, a new population of waterwheel was discovered in New Jersey, and other populations have been reported from New York and Virginia.



## Environmental Impacts

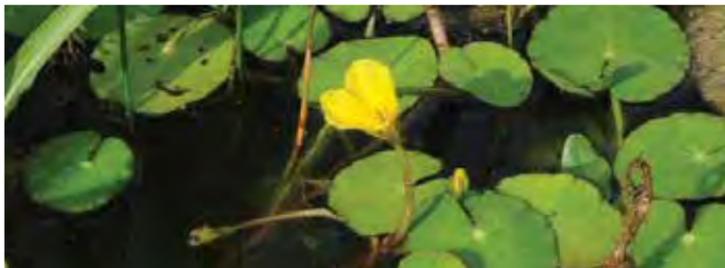
Due to its carnivorous nature, competition with other native carnivorous species like bladderworts is likely. Studies are needed to determine impacts on aquatic invertebrate communities and to the food web.

United States Distribution



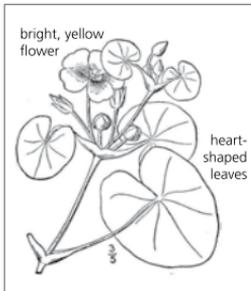
# Yellow Floating Heart

*Nymphoides peltata*



## Species at a Glance

This aggressive aquatic perennial was introduced as a garden ornamental from eastern Asia and has since spread throughout the United States and Canada. It forms dense mats of vegetation in the water that exclude native species and alter the ecology of waterways.



## Identification

**Leaves:** Shiny, green, heart-shaped or nearly circular leaves are 5-15 cm (2-6 inches) long and are set on **stalks** that float at the water's surface. Leaves are frequently seen with reddish-purple blotches and are slightly wavy or rippled. They are **alternately** arranged along the main stem and **oppositely** arranged on the flower stems.

**Flowers:** Occur from June to October and are produced on **stalks** just above the water's surface. They can be either solitary or in clusters of up to five. Flowers have five yellow petals that have distinctive fringed edges, five **sepals**, and five **stamens**.

**Fruit/Seeds:** 2.5 cm (1 in) long **fruit** capsules contain numerous flat, oval seeds with "hairy" edges. When ripe, they split open, releasing the seeds to float on the surface of the water.

**Roots:** Bottom-rooted with long branched stems that reach about 1 m (3 ft) or more.

## Similar Species

Yellow floating heart may be confused with the native spatterdock (*Nuphar variegata*) or watershield (*Brasenia schreberi*). Spatterdock has larger leaves that grow to 30 cm (12 in) or more and has yellow flowers in the shape of a ball with six or more petals. Watershield has distinctive oval-shaped leaves, an inconspicuous purple flower, and can be easily recognized by a gelatinous slime that covers the stem and underside of the leaves.

## Habitat

Most commonly found in slow-moving waters about 0.5-4 m (1.5-13 ft) deep, such as rivers, lakes, reservoirs, ponds, and swamps, and can even grow on damp mud.

## Spread

Because of its popularity in the aquarium trade, yellow floating heart can be easily purchased on the internet. Spread can occur when it escapes outdoor water gardens during flooding events, or when it is intentionally discarded into waterways. Since it spreads both by seed and **fragmentation**, pieces of plant and stiff seed hairs can be moved to new areas on water currents or as they hitchhike on the feathers or fur of waterfowl and other wildlife.

## Distribution

Native to Eurasia and the Mediterranean region, yellow floating heart was introduced as an ornamental plant into the United States. In the Mid-Atlantic region, it can be found in Delaware, New Jersey, New York, North Carolina, Maryland, Pennsylvania, and Washington DC.



## Environmental Impacts

Yellow floating heart grows in dense patches that negatively impact wildlife habitats by outcompeting ecologically important native plants and creating stagnant areas of low oxygen under the mats. These mats also make recreational opportunities such as angling, boating, swimming, and paddling difficult.



# Yellow Iris

*Iris pseudacorus*



## Species at a Glance

This exotic member of the iris family, also called the yellow flag, is commonly found in wetland regions of the United States. It is an **emergent** aquatic perennial with showy yellow flowers that can grow on average 0.3-0.9 m (1- 3 ft) tall, although some can reach up to 2.1 m (7 ft).



## Identification

**Leaves:** Long, broad, flattened, and sword-shaped leaves are usually dark green in color, pointed at the ends and overlapped at the base. Leaves can grow up to 2.5 cm (1 in) wide.

**Flowers:** There are usually 2-3 flowers on each **stalk** that have bright yellow to cream-colored petals with **sepals** outlined in purple and brown. They are 8 -10 cm (3.1-3.9 in) in diameter and bloom June through August.

**Fruit/Seeds:** Numerous smooth, flattened seeds grow in small oblong-shaped capsules that are roughly 5 cm (2 in) long. Capsules grow in clusters at the base of the flower and have the ability to float.

**Stems/Roots:** Fleshy and form from a single-branched stem. They are 10-30 cm (3.9-12 in) long.

## Similar Species

Native look-a-likes include cattails (*Typha spp.*), bur-reeds (*Sparganium spp.*), and the blue flag iris (*Iris versicolor*). Cattails look similar during spring growth, except that their leaves are arranged in rounded layers rather than flat like the yellow iris. Native irises have thinner leaves and blue-purple flowers instead of yellow.

## Habitat

The yellow iris is found mainly in wetland areas like marshes and the shores of lakes, ponds, and streams; however, they have a high tolerance for drought and can survive long periods in dry, acidic, and low-oxygen soils.

## Spread

The yellow iris reproduces **vegetatively** through horizontal underground stems called **rhizomes**, which form into roots, allowing it to re-grow new plants.

## Distribution

Native to Europe, western Asia, northern Africa, and the Mediterranean region, yellow iris was brought to the United States as an ornamental plant that quickly spread to uncultivated areas and is now established in over 40 states, Lake Erie, and throughout the entire Mid-Atlantic region.



## Environmental Impacts

The roots of the yellow iris are sturdy and connect hundreds of flowering plants underground, congesting water flow and leaving no room for native wetland plants to grow. It is also poisonous, harming fish and animals that touch or eat it. It can cause skin irritation when touched, so caution should be used when trying to remove it.



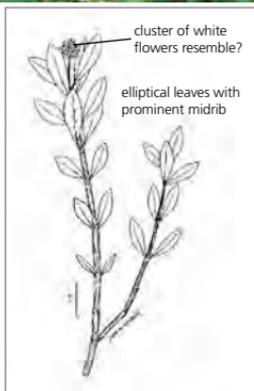
# Alligatorweed

*Alternanthera philoxeroides*



## Species at a Glance

Alligatorweed is a fast-growing perennial plant considered to be one of the world's worst weeds because of its ability to grow both over land and in water. In aquatic environments, it forms dense mats that begin at the shoreline and grow across the surface. In some cases, mats can reach completely across slow moving rivers and can be robust enough to support the weight of a man.



## Identification

**Leaves:** Simple leaves are **opposite**, elliptical to lance-shaped, shiny, and up to 10 cm (4 in) long with a prominent **midrib** and smooth **margins**. Soft, whitish hairs are found in the leaf **axis**.

**Flowers:** Distinctive flowers are white, papery, fragrant, and resemble a white clover. While appearing to be a single flower, they are actually a cluster of 6-10 small florettes that are about 1.3 cm (0.5 in) in diameter and grow on a **stalk** that can be up to 7.6 cm (3 in) long. Flowers generally appear from April through October.

**Fruit/Seeds:** Very small **fruits** develop a single seed.

**Stems/Roots:** Smooth, hollow stems can be single or branched, and sprawl out along the ground or out across the water. Each node on the stem can produce a new stem or root, and mats of **creeping** stems can be up to 10 m (33 ft) long. Stems are particularly large and hollow when growing in water.

## Similar Species

Alligatorweed is often confused with other members of the *Alternanthera* family such as sessile joyweed (*A. sessilis*) and lesser joyweed (*A. denticulata*); however, alligatorweed is the only aquatic member of this family. Lesser joyweed is smaller in size and has a small, **stalkless** cluster of white flowers. Water primrose (*Ludwigia peploides*) is another look-alike; however, its leaves are **alternatively** arranged, and it has a large yellow flower. One of the main identifying features of alligatorweed is the hollow stems on mature plants.

## Habitat

While alligatorweed is usually found in aquatic habitats such as lakes, ponds, rivers, or along shorelines, it has the ability to grow in a variety of areas including many terrestrial habitats. When growing on land, this plant forms smaller, tougher leaves. When growing in water, it may be rooted in the substrate, or exist as a free-floating mat or **tussock**.

## Spread

Growing and spreading quickly, alligatorweed reproduces **asexually** by **fragmentation**. Since new stems and roots can develop from a single node, a short fragment can regenerate into a new plant. Fragments are moved by water currents, and through human activities such as boating and fishing.

## Distribution

Native to South America, alligatorweed is believed to have been introduced to the United States as a stowaway in the ballast water of transoceanic ships. It was first documented in Alabama in 1897, and is now found in coastal states from Virginia to Texas, the Tennessee Valley, Puerto Rico, and California.



## Environmental Impacts

The dense, tangled mats formed by alligator weed can be up to 1 m (3 ft) thick and have extensive root systems. Excessive growth of this plant clogs waterways, smothers native plants, prevents light and oxygen from entering the water column, and impedes water flow, which can lead to flooding damage. While some invertebrates may use these mats for habitat, this plant has no known direct food value to wildlife.



# Asian Spiderwort

*Murdannia keisak*



## Species at a Glance

Asian spiderwort is a shallow water succulent plant and member of the dayflower family. It produces long trailing shoots that root at **nodes**, reaching heights of approximately 46 cm (18 in). It can be found in water depths of up to 7.5 cm (3 in).



## Identification

**Leaves:** **Alternate** leaves are 2.5-7.5 cm (1-3 in) long and have parallel veins, long narrow blades, and oblong bases that wrap around the stem.

**Flowers:** Growing from the leaf **axils** in groups of 2-4, flowers consist of three pink to violet petals and three small, thin green **sepals**. Each flower lives for only one day and blooms from late August to October.

**Fruit/Seeds:** Each flower produces a capsule containing thousands of very small seeds.

**Stems/Roots:** Weak and sprawling stems are 30-76 cm (12-30 in) long and root extensively wherever a **node** touches damp soil.

## Similar Species

Asian spiderwort may be confused with other species in the dayflower family such as the climbing dayflower (*Commelina diffusa*), which has three bright blue petals on each flower, and Whitemouth dayflower (*Commelina erecta*), which has bright blue flowers with only two petals.

## Habitat

Most common in coastal marshes, Asian spiderwort can also be found inland in freshwater marshes, ditches, creeks, rivers, swamps, bogs and along the edges of ponds, lakes, and streams.

## Spread

After escaping cultivation, Asian spiderwort established in the wild where it continues to spread by both seeds and **fragmentation**. Seeds, stems, and roots can be carried by wildlife and flooding to new locations where the plant can start new populations.

## Distribution

Native to China, Japan, Korea, and Tibet, the earliest record of Asian spiderwort in the United States dates back to the 1920s and early 1930s when it was thought to have been brought to South Carolina mixed in rice seeds imported for growing. It is now found in all coastal states from New Jersey to Louisiana, inland in Arkansas, Kentucky, and Tennessee, and in the Pacific Northwest in Washington and Oregon.



## Environmental Impacts

This aggressive plant establishes itself in freshwater wetlands and forms dense mats that crowd out native vegetation and clogs waterways.



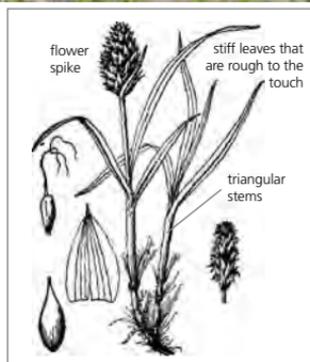
# Asiatic Sand Sedge

*Carex kobomugi*



## Species at a Glance

Asiatic sand sedge, also called Japanese sedge, is a coarse, stout, perennial sedge that grows 10-30 cm (4-12 in) in height and is adapted to coastal beaches and dunes. It forms extensive colonies through cord-like **rhizomes** that extend many feet under the sand and produce new shoots.



## Identification

**Leaves:** Young leaves are yellow-green in color, stiff, and rough to the touch along the edges. Older **basal** leaves are somewhat wider, darker green in color, and leathery to the touch. The edges are **serrated**, which can be seen with the help of a hand lens. Leaves are 3-6 mm wide and are often longer than the triangular stems.

**Flowers:** Individual plants have either male or female flowers that are arranged in dense clusters or "**spikes**" at the end of a flowering **stalk**. Male flower **spikes** are cylindrical in shape and measure 3-4 cm long. Female flower **spikes** are more slender and typically longer measuring 3-6 cm. Flowering occurs from April to June.

**Fruit/Seeds:** A papery sac called a **perigynium** encloses the female flowers, each of which develops into a single-seeded **fruit** called an **achene**.

**Stems/Roots:** The base of the triangular stems is covered in brown scales.

## Similar Species

Asiatic sand sedge resembles American beach grass (*Ammophila breviligulata*), and beach panic grass (*Panicum amarum*). Leaves of Asiatic sand sedge are longer and more tapered than the look-a-like grasses, have a yellow-green rather than bluish-green cast, and small teeth along the **margin**.

## Habitat

Asiatic sand sedge grows on dunes and on the upper parts of ocean beach wash flats that have recently been disturbed by ocean storms. Like American beach grass, it appears to create more habitat for itself by trapping wind-blown sand to form dunes. Sand burial appears to stimulate the growth of **rhizomes**.

## Spread

Soon after the plant was discovered in the United States, Asiatic sand sedge was observed to be potentially useful for stabilizing sand dunes, and thus was planted intentionally on dunes in New Jersey and other beaches on the east coast. This plant likely made its way to New England through either intentional planting or the water dispersal of plant fragments or seeds. While it does produce seeds, germination rates are low and primary spread from this species occurs through an extensive **rhizome** system.

## Distribution

Native to coastal Japan, China, and Korea, Asiatic sand sedge was first reported in the United States in New Jersey in 1929. It was thought that it washed ashore from shipwrecks that were carrying oriental porcelain and using Asiatic sand sedge as a packing material. It can now be found down the east coast from Massachusetts to North Carolina, and also in Oregon.



## Environmental Impacts

Asiatic sand sedge has the ability to form dense stands on coastal dunes. It has been found in densities of up to 200 plants per square meter. This density effectively excludes native beach grasses and makes dunes more susceptible to being blown out.



# Beach Vitex

*Vitex rotundifolia*



## Species at a Glance

Beach vitex is a fast-growing, perennial, woody shrub of coastal sand dunes that can reach heights of 0.5-1 m (1.6-3.3 ft). It has a strong impact on the native flora and fauna along the Carolina coasts, including shading out native plants and disrupting nesting sites for sea turtles. Active community involvement, strategic mapping, and eradication efforts are currently underway to limit the impact this species has on U.S. coastlines.



## Identification

**Leaves:** Oval-shaped leaves are **oppositely** arranged, simple, semi-waxy, smooth, and pale green on the upper side while greyish-white on the underside. Both sides of the leaves are covered in dense fine hairs. Size is typically 5 cm (2 in) long and foliage has a spicy fragrance when crushed.

**Flowers:** Blue to purple flowers are fragrant, 2.5 cm (1 in) across, and are in short **inflorescences** out of the leaf **axils**. Flowering occurs in the summer.

**Fruit/Seeds:** Round, 0.6 cm (.25 in) wide **fruits** are purplish-black when ripe.

**Stems/Roots:** Woody stems have square branchlets with fine wooly hairs. The stems grow horizontally along the ground, often rooting at the **nodes** and forming mats that can grow over 18 m (60 ft) long.

## Similar Species

Beach vitex has several native look-a-likes including silver leaf croton (*croton punctatus*), sea beach amaranth (*Amaranthus pumilus*), and seashore elder (*Iva imbricata*).

Silver leaf croton has unpaired leaves with brown dots on the undersides of the leaves that can be seen with magnification. Sea beach amaranth has red stems and leaves that are crinkled. Seashore elder has long linear leaves and doesn't have the round **fruits** found on beach vitex.

## Habitat

An obligate sand-dune species, beach vitex can be found at low elevations on beaches, sand dunes, and rocky shorelines. It is highly drought and salt tolerant and grows best in full sun and sandy or well-drained soils. This plant can currently survive in five U.S. hardiness zones, which increases the likelihood that it will expand its range in the United States.

## Spread

Beach vitex is a prolific seed producer, but can also reproduce from stem fragments. Seeds and broken off stems can float on water currents and be carried to other beaches. Birds can also facilitate spread as they eat seeds and distribute them in new areas. Seeds and cuttings that are chipped up and spread as mulch may have also helped this species to spread.

## Distribution

Native to Japan and Korea, Beach vitex was introduced to the southeastern United States in in the mid-1980s as an ornamental landscape plant and for sand dune stabilization. Along the coasts of North and South Carolina, beach vitex escaped cultivation and has taken over oceanfront dunes. This species can also be found in Hawaii, Alabama, and Florida.



## Environmental Impacts

This rapidly growing and sprawling shrub crowds out native dune plants and allows little light to reach the soil surface. Because of the structure of its root system, beach vitex does not make it an ideal dune stabilizer, causing higher rates of erosion. It also threatens the endangered loggerhead sea turtle's nesting habitat, as well as habitat for rare and threatened plants.



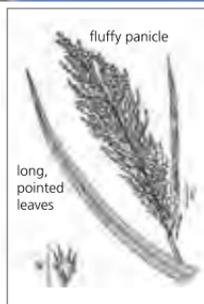
# Common Reed (Phragmites)

*Phragmites australis*



## Species at a Glance

Phragmites is a perennial long-lived grass that can grow 1.8-4.6 m (6-15 ft) high in stands that exclude almost all other vegetation. While phragmites is native to North America, the introduction of a non-native strain from Europe rapidly and aggressively expanded throughout the United States, replacing much of the native reed.



## Identification

**Leaves:** Broad, pointed, elongate leaves are typically 20-60 cm (7.9- 24 in) long and 1-5 cm (0.4-2 in) at their widest point. They arise from thick vertical **stalks**. Foliage is gray-green during the growing season.

**Flowers:** Bushy clusters called **panicles** grow 15-40 cm (5.9-16 in) long in late July and August. They are usually purple or golden in color, but as seeds mature the **panicles** begin to look “fluffy” due to hairs on the seeds, and they take on a gray sheen.

**Stems/Roots:** Rigid stems feel rough to the touch and reach 4.6 m (15 ft) in height next to dead stems from previous growth. Below ground, phragmites forms a dense network of roots several meters in depth and includes **rhizome runners**, which can grow 3 m (10 ft) or more in a single season.

## Similar Species

Reed canary grass (*Phalaris arundinacea*) has a similar appearance to phragmites but is much smaller and has a membranous **ligule**. Giant reed (*Arundo donax*) also has a similar appearance and habitat but has a hairy **lemma** and a hairless **spikelet stalk**.

## Habitat

Phragmites is abundant along the borders of lakes, ponds, and rivers in tidal and nontidal brackish and freshwater marsh communities, roadsides, and disturbed areas. It does not tolerate rapidly moving water.

## Spread

Spread occurs mainly through vegetative means such as **rhizome** and **stolon** fragments. **Rhizomes** can break off and be washed downstream, becoming established in new areas. Phragmites also produces an abundance of wind-dispersed seeds, although seed viability is typically low. Heavy machinery may transport phragmites along roadsides between sites.

## Distribution

Invasive strains of phragmites, which were introduced in the late 1800s, are now widespread throughout the lower 48 states and southern Canada. It can be found in every Mid-Atlantic state.



## Environmental Impacts

Dense stands of invasive phragmites can crowd out native plant species, alter marsh hydrology, alter wildlife habitat, and increase fire potential. It blocks light to other plants and emits a toxin that allows it to outcompete native species, quickly turning once biologically diverse wetlands into monocultures.

United States Distribution



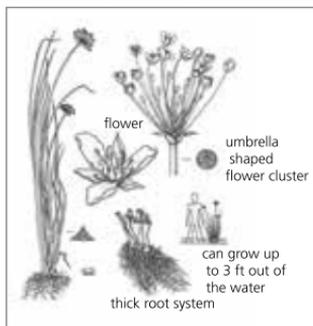
# Flowering Rush

*Butomus umbellatus*



## Species at a Glance

Flowering rush is a perennial aquatic herb that can grow both as an **emergent** plant along shorelines and a **submersed** plant in lakes and rivers. It often goes unnoticed among other wetland plants until it blooms a distinctive spray of attractive flowers in late summer and early fall.



## Identification

**Leaves: Emergent** leaves are stiff, narrow, green, and can grow up to 0.9 m (3 ft) above the water's surface. Leaf tips may be spirally twisted.

**Submersed** leaves are limp under water and do not flower.

**Flowers:** Grow in umbrella-shaped clusters on a long **stalk** with each flower made up of three petals, three **sepals**, and red **anthers**. Flowers are approximately 2.5 cm (1 in) across and are typically white, pink, or purple. Flowering occurs in late summer to early fall and only occurs on **emergent** plants.

**Fruit/Seeds: Pistils** ripen into dark brown **fruits** filled with tiny seeds.

**Stems/Roots:** Green stems are triangular in cross-section. The extensive root system is a thick **creeping rhizome**. **Bulblets** that form on the **rhizome** can easily break off when disturbed and form a new plant.

## Similar Species

Leaves of flowering rush resemble another shallow water plant, bur-reed (*Sparganium spp.*); however, the leaves of the bur-reed are V-shaped and its female flowers appear as small spiked balls. Bur-reed grows 0.3-1.2 m (1-4 ft) tall.

## Habitat

Flowering rush prefers shallow and slow-moving waters but will inhabit deeper waters. It grows well in riparian zones, watercourses, and wetlands such as ditches, marshes, lakes, or streams. It cannot grow in shade and requires wet soil.

## Spread

Once in a watershed, flowering rush spreads locally by underground **rhizomes**, root pieces, and seeds. Wildlife, water movement (water or ice), anglers, and boaters can carry this plant to new areas. Its use as a water garden plant could have also contributed to its spread over long distances.

## Distribution

Native to Europe and Asia, flowering rush was brought to North America as a garden plant. It is present in states along the U.S./Canadian border, extending north to the tip of Quebec and south to Illinois. In the Mid-Atlantic, flowering rush is found in New York and Pennsylvania.



## Environmental Impacts

Flowering rush can crowd out native species and the large amount of underground **rhizomes** can harm fish and other wildlife by destroying food sources and habitats. It can also interfere with recreational activities such as swimming and boating.



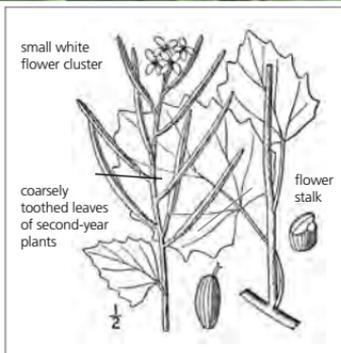
# Garlic Mustard

*Alliaria petiolata*



## Species at a Glance

Garlic mustard is a cool season biennial herb with leaves that give off a garlicky odor when crushed. First-year plants appear as a **rosette** of 4-8 green leaves that grow close to the ground and remain green all winter. In the spring, the **rosettes** develop into flowering plants that quickly dominate the forest floor, threatening native plants and forest communities throughout the Eastern and Midwestern United States.



## Identification

**Leaves:** First-year **rosettes** have dark green, kidney-shaped leaves with scalloped **margins** and deep veins that give them a wrinkled appearance. In the second spring, a flower **stalk** rises from the **rosette** bearing **alternate**, triangular to heart-shaped, coarsely toothed leaves that smell like garlic when crushed. These flowering plants reach 0.6-1 m (2-4 ft) in height.

**Flowers:** Clusters of small white flowers appear at the end of an erect **stalk** on only second-year plants. Each flower has four petals and blooming occurs from late April through June.

**Fruit/Seeds:** Seeds are produced in long slender capsules and become shiny black when mature. By late June, when most garlic mustard plants have died, they can be recognized only by the erect **stalks** of dry, pale brown seed pods that remain throughout summer.

**Stems/Roots:** Single stems are weak and have a white, slender taproot that is "S"-shaped at the top.

## Similar Species

Cut-leaved toothwort (*Cardamine concatenata*), sweet cicely (*Osmorhiza claytonii*), and early saxifrage (*Micranthes virginensis*) are native white-flowered plants that occur in the same habitat and may be mistaken for garlic mustard. Cut-leaved toothwort is low-growing but has narrow, finger-like leaves. Sweet cicely has fern-like leaves and flowers with five petals, and early saxifrage has five white petals.

## Habitat

Garlic mustard usually grows in the moist shaded soils of river floodplains, forests, roadsides, edges of woods and trails, and forest openings. It thrives in shady conditions, but can tolerate sunny habitats, usually resulting in smaller flowering plants. Disturbed areas are most susceptible to rapid invasion and dominance.

## Spread

A single garlic mustard plant can produce thousands of seeds that can scatter as far as several meters from the parent plant. These seeds can stay dormant for 20 years before germinating and remain viable for 5-8 years. Depending on the conditions, garlic mustard can either self-fertilize or be cross-pollinated by a variety of insects. While water may transport the seeds, they don't float well and are not carried far by wind; therefore, long distance dispersal is most likely through animals that can carry the seeds in their fur, or through human-mediated pathways.

## Distribution

Originally from Europe, garlic mustard was first recorded in the United States in 1868 from Long Island, New York. It was most likely introduced by settlers for food and medicinal purposes. By 1991 it had invaded 28 Midwestern and Northeastern states, and can be found in all states throughout the Mid-Atlantic region.



## Environmental Impacts

Garlic mustard aggressively monopolizes resources needed by native plants, such as light, moisture, nutrients, soil, and space. Wildlife that depend on native plants blooming early in the spring are deprived of essential food sources when garlic mustard replaces them, and very few insects, deer, or other herbivores will eat it.



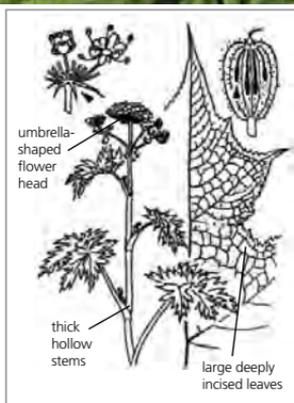
# Giant Hogweed

*Heracleum mantegazzianum*



## Species at a Glance

Giant hogweed, also known as giant cow parsnip, is a perennial herb and member of the carrot and parsley family that can grow 4.5-6 m (15 to 20 ft) high. While the plant is beautiful, it is also dangerous and direct contact with its sap can cause blisters and burns on the skin. It is one of the few North American invasive plants that can cause both human health impacts and ecological damage.



## Identification

**Leaves:** Large **compound leaves** are lobed, deeply incised, and 1-1.5 m (3-5 ft) wide. Hairs on the undersides are stiff, dense, stubby, and only about 0.25 mm long. **Petioles** have short, coarse, white hairs at the base.

**Flowers:** Numerous white flowers form a large, flat-topped, umbrella-shaped head that is up to 0.8 m (2.5 ft) across. Flowering occurs from late spring through mid-summer.

**Fruit/Seeds:** Up to 100,000, 1 cm (0.5 in) long, winged, flattened, oval seeds form in late-summer. The seeds, originally green, turn brown as they dry.

**Stems/Roots:** Thick hollow stems are generally 2.5-8 cm (1-3 in) in diameter, but can reach up to 10 cm (4 in). They are marked with dark purplish blotches and raised nodules. Leaf **stalks** are spotted, hollow, and covered with sturdy bristles that are prominent at the base of the **stalk**. Stems are also covered with less prominent hairs.

## Similar Species

While it's much larger than most native plants, giant hogweed can be mistaken for cow parsnip (*Heracleum lanatum*), purple-stemmed Angelica (*Angelica atropurpurea*), and poison hemlock (*Conium maculatum*). Cow parsnip only grows 1.5-2.5 m (5-8 ft) tall and the deeply ridged stems can be green or slightly purple without the dark blotches and raised nodules. Purple-stemmed Angelica has smooth, waxy green to purple stems with no bristles or nodules and a softball-sized cluster of greenish-white or all white flowers. Poison hemlock is shorter than giant hogweed, growing only 1-3 m (4-9 ft). While the stem has some purple blotches, it is waxy and the entire plant is smooth and hairless and the leaves are fern-like with bright, glossy, green leaves.

## Habitat

Giant hogweed can colonize a wide range of habitats, but prefers rich damp soils such as those found along abandoned railroad right-of-ways, roadside ditches, stream banks, or other moist disturbed areas.

## Spread

Because of its unique size and impressive flower head, giant hogweed was probably introduced to the United States and Canada as an ornamental plant for arboreta and Victorian gardens. It was also a favorite of beekeepers because the flower heads provide a large amount of food for bees. Giant hogweed survives from one growing season to the next by forming buds that can endure a period of dormancy in the winter. The numerous seeds produced by this plant can be spread by animals, surface runoff, wind, or by human activities and can remain viable in the soil for up to 10 years.

## Distribution

Native to Europe and Asia, Giant Hogweed escaped cultivation and has now become naturalized in a number of areas throughout the United States and Canada. In the Mid-Atlantic region, it can be found in New York, Pennsylvania, and North Carolina.



## Environmental Impacts

Colonies of giant hogweed can form dense stands that crowd out slower growing native plants. The sap from broken stems, leaves, roots, flowers, or seeds, can cause irritation in the form of severe blisters, burns, painful sores, and purplish blackened scars when it comes in contact with skin.

United States Distribution



# Giant Knotweed

*Fallopia sachalinensis*



## Species at a Glance

Giant knotweed is an herbaceous perennial and member of the buckwheat family. It forms large colonies of erect stems which are woody in appearance and can reach heights over 3.7 m (12 ft).

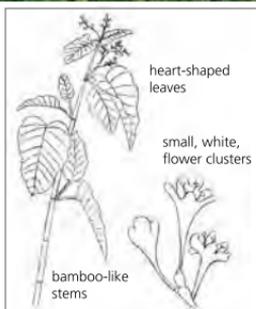
## Identification

**Leaves:** Large rounded leaves **alternate** on the stem and reach over 0.3 m (1 ft) in length. They have heart-shaped bases and rounded lobes. Thin wavy hairs are present on the underside of the leaves in June through mid-September.

**Flowers:** Small flowers reach about 10 cm (3.9 in) in length and range in color from a creamy white to greenish-white. They grow in short branched clusters from leaf **axils** at the ends of stems and appear from August to October.

**Fruit/Seeds:** Three-sided seeds are shiny, brown to black, egg-shaped, and have a paper-like texture.

**Stems/Roots:** Smooth, hollow, jointed stems are swollen at the **nodes**, light green in color, and resemble bamboo shoots.





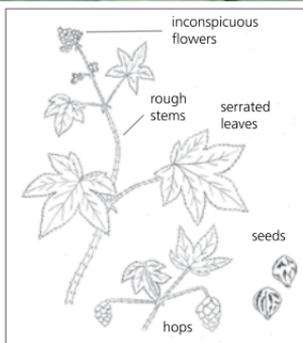
# Japanese Hop

*Humulus japonicus*



## Species at a Glance

Japanese hop is a fast-growing, herbaceous, annual climbing vine and member of the hemp family. It can climb to heights of 3 m (10 ft) or more with the help of many small hooked prickles that cover the stem and can cause irritation to bare skin.



## Identification

**Leaves:** **Opposite, palmate** leaves are approximately 5-10 cm (2-3.9 in) in length and have rough, **serrated** edges. They are divided into 5-9 lobes with downward pointing prickles and down-curved **bracts** at their base.

**Flowers:** Because they lack petals and are green in color, the flowers can be inconspicuous. They bloom in clusters about 5 cm (2 in) in length in early to mid-summer.

**Fruit/Seeds:** Green hops produced by female plants contain oval, yellowish-brown seeds, which can remain viable for up to three years.

**Stems/Roots:** Rough stems, which are covered in tiny hooked hairs, can reach 2.5-11 m (8-35 ft) in length and help the plant climb.

## Similar Species

May be confused with common hop (*Humulus lupulus*), which typically has three-lobed leaves and the upper leaves occasionally lack lobes altogether. The leaf stems of common hop are also shorter than the leaves. The best way to distinguish Japanese hop from other species is the down-curved **bracts** and sharp prickles.

## Habitat

Japanese hop grows dense, nearly continuous stands in floodplain areas along river and stream banks, roadsides, open fields, and woodlands; or wherever the soil is moist. It can grow in full sun or shade in sandy, clay, acidic, or neutral soil.

## Spread

Numerous small seeds disperse by wind and water movement, allowing Japanese hop to spread to new locations. Seeds can remain viable for up to three years. It can also reproduce **vegetatively**, starting entirely new populations off of small plant fragments.

## Distribution

Native to Japan and eastern China, Japanese hop was introduced to the United States as an ornamental garden plant and is now growing throughout the Eastern and Midwestern United States. It can be found in all Mid-Atlantic states.



## Environmental Impacts

Japanese hop can form dense, almost solid stands that outcompete native vegetation. It can be removed by hand-pulling before the seeds ripen (August through September), but protection is needed for the skin because irritation and blistering can occur from the hooked hairs covering the vines.

United States Distribution



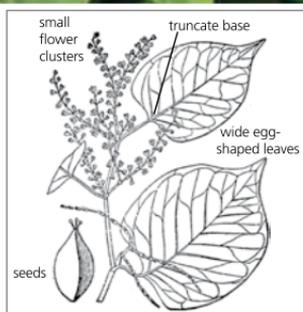
# Japanese Knotweed

*Fallopia japonica*



## Species at a Glance

Japanese knotweed is a shrub-like herbaceous perennial that gets the nickname “elephant ear bamboo” from its stems that resemble bamboo when mature. It can reach upright heights of over 4 m (13 ft).



## Identification

**Leaves:** Wide, triangular to egg-shaped leaves are pointed at the tips and arranged **alternately** along the stem. Size varies, but average is about 15 cm (5.9 in) long by 8-10 cm (3.1-3.9 in) wide. Leaf stems are often reddish in color and leaf bases are essentially straight across (**truncate**).

**Flowers:** Small, attractive, greenish to white flowers occur in branched clusters about 10-13 cm (3.9-5.1 in) long in the summer.

**Fruit/Seeds:** Soon after flowering, small winged **fruits** called **nutlets** are produced. Triangular seeds are shiny and small, about 0.3 cm (0.1 in) long.

**Stems/Roots:** Smooth, stout, hollow stems are swollen at the leaf joints and resemble bamboo, especially in older plants. Like all members of this family, the base of the stem above each joint is surrounded by a thin membranous **sheath** called an **ocrea**.

## Similar Species

Giant knotweed (*Fallopia sachalinensis*) occurs in some of the same areas as Japanese knotweed but can be distinguished by its larger leaves with heart-shaped bases instead of the characteristic **truncate** leaf base. It also lacks egg-shaped leaves and the stems that resemble bamboo.

## Habitat

Found in moist, open, partially shaded habitats, Japanese knotweed has been reported along riverbanks, wetlands, roadways, hillsides, and disturbed areas in a variety of soil types and pHs. It also tolerates adverse conditions such as high temperatures, high salinity, drought, and floods.

## Spread

Long stout **rhizomes**, which are capable of rapidly producing new plants, result in thick colonies. Plant fragments, seeds, and **rhizomes** can be spread naturally by water and wind, but also by human interactions.

## Distribution

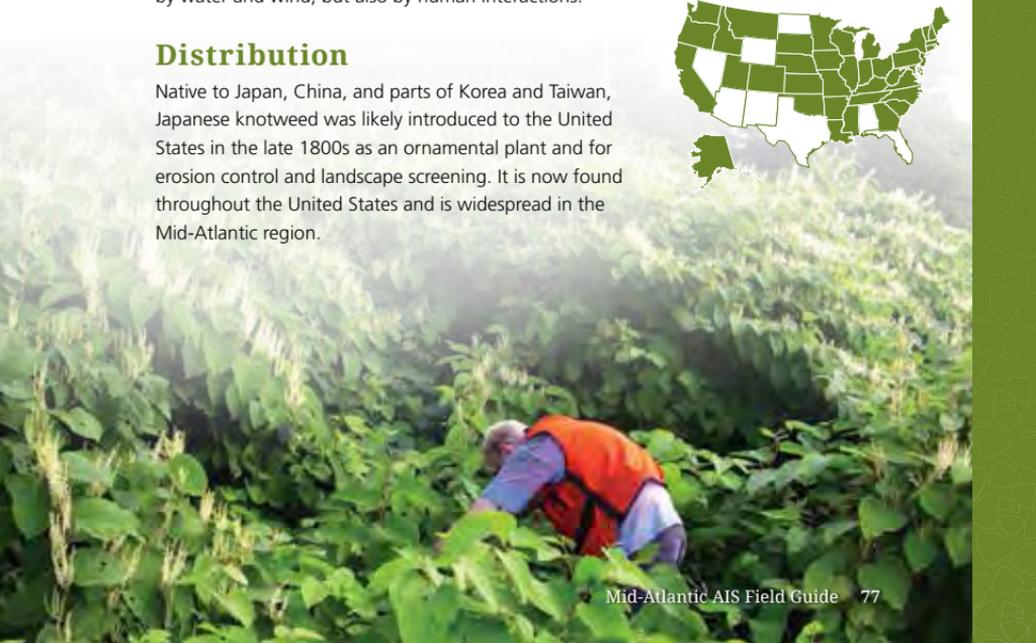
Native to Japan, China, and parts of Korea and Taiwan, Japanese knotweed was likely introduced to the United States in the late 1800s as an ornamental plant and for erosion control and landscape screening. It is now found throughout the United States and is widespread in the Mid-Atlantic region.



## Environmental Impacts

Japanese knotweed emerges early in the spring and grows quickly and aggressively. It forms dense mats that crowd and shade out native plants and grasses along creeks, making riverbanks less stable and more likely to shear off during flooding.

United States Distribution



# Japanese Stilt Grass

*Microstegium vimineum*



## Species at a Glance

Japanese stilt grass is an annual, herbaceous, sprawling grass that resembles miniature bamboo. It germinates in the spring and grows slowly through the summer months, reaching a canopy height of 30-61 cm (12-24 in).

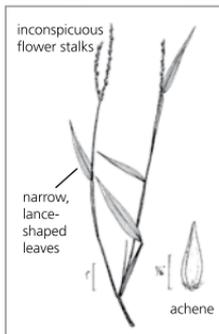
## Identification

**Leaves:** Pale green leaf blades are 3-8 cm (1.2-3.1 in) in length. They are narrow, asymmetrical, taper at both ends, and are lightly hairy, **alternating** along a branched **stalk**. A distinguishing characteristic is a pale silvery stripe of reflective hairs along the **midrib** of the upper surface.

**Flowers:** Flattened, trapezoid-shaped flowers grow in **spikes** on slender **stalks** about 3-8 cm (1.2-3.1 in) long in late August to September.

**Fruit/Seeds:** Dry **fruits** called **achenes** are produced soon after flowering, usually in early October.

**Stems/Roots:** The weak, somewhat reclining stems are hairless and branched, rooting at the lower **nodes**.



## Similar Species

The native perennial whitegrass (*Leersia virginica*) is similar to Japanese stilt grass, but it lacks the silver stripe along the **midrib** and it flowers earlier in August. The **nodes** of stilt grass are also smooth, while whitegrass has hairy **nodes**. In the fall, stilt grass turns yellow to pale purple, while whitegrass stays green.

## Habitat

Japanese stilt grass occurs in a wide variety of habitats, including moist soils of open woods, floodplain forests, wetlands, fields, roadsides, ditches, utility corridors, and gardens. It readily invades areas subject to disturbances such as mowing, tilling, foot traffic, and flooding.

## Spread

This species spreads by roots that grow from **nodes** along the stems that come in contact with the ground. It also spreads through a high production of seeds that disperse by water currents during floods, or by contaminated materials, such as hay, soil, and potted plants, or on footwear. Seeds can remain viable for five or more years before they germinate.

## Distribution

Native to Japan, Korea, China, Malaysia, and India, Japanese stilt grass was introduced into the United States in 1919 due to its use as a packing material for porcelain. It is now invasive in several states and has invaded all states in the Mid-Atlantic region.



## Environmental Impacts

Japanese stilt grass rapidly spreads to form extensive mats that displace native plant species that are unable to compete. It can alter natural habitats by changing soil chemistry and creating low light conditions that shade out other species.



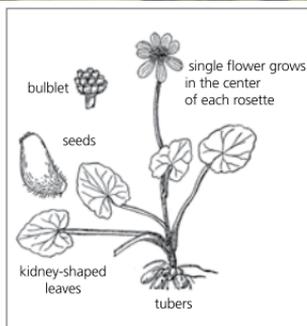
# Lesser Celandine

*Ranunculus ficaria*



## Species at a Glance

Lesser celandine, also known as fig buttercup and pilewart, is a low-growing, perennial, flowering herb that completes its life cycle during the winter and spring. When in bloom, large infestations appear as a thick green carpet with yellow dots spread across the forest floor.



## Identification

**Leaves:** Kidney to heart-shaped leaves have both smooth and coarse toothed edges and come together to form a **rosette**. Leaves are tender, **stalked**, and coloration is a shiny, almost lustrous, dark green.

**Flowers:** A single flower with 8-12 symmetrical petals blooms in the center of each **rosette** in March and April. They are a buttery yellow color with slightly darker centers and grow to be about 2.5 cm (1 in) wide.

**Stems/Roots:** Tiny cream-colored **bulblets** are produced in the stem **axils** and become apparent later in the flowering period. Roots produce numerous finger-like **tubers** that are easily visible when the plant is pulled up and are used to store energy for early growth in the spring.

## Similar Species

Native marsh marigold (*Caltha palustris*) also has kidney-shaped leaves and yellow flowers but does not produce **tubers** or form a continuous carpet of growth. Other look-a-likes include celandine (*Chelidonium majus*) and celandine poppy (*Stylophorum diphylllum*), both of which belong to the poppy family and have flowers with only four petals.

## Habitat

While lesser celandine is mostly found in moist forested floodplains with sandy soils, it can also occur in drier upland areas.

## Spread

Lesser celandine spreads using an abundant network of **tubers** and **bulblets**, which easily separate from the parent plant to form a new independent plant. **Tubers** can be unearthed and scattered around to new locations by animal and human activity, hitchhiking on equipment, or by flooding events.

## Distribution

Native to Eurasia, including Europe, northern Africa, western Asia, Caucasus, and Siberia, lesser celandine was introduced to the United States as an ornamental plant and many colorful varieties are still available commercially. It is reported as an invasive in at least twenty states in the United States, including all Mid-Atlantic states except North Carolina and South Carolina.



## Environmental Impacts

Lesser celandine emerges before most native species in the spring, giving it a competitive advantage and allowing it to form a thick blanket of leaves across the forest floor, preventing native species from penetrating.

United States Distribution



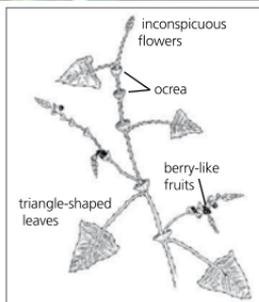
# Mile-a-minute

*Persicaria perfoliata*



## Species at a Glance

Mile-a-minute, also called Asiatic tearthumb, is an herbaceous, annual, trailing vine that can reach lengths of up to 6 m (20 ft). It survives by using its recurved barbs to attach to and climb over other plants in order to reach areas of high light intensity, smothering and weakening them in the process.



## Identification

**Leaves:** Light green leaves are shaped like distinctive equilateral triangles. They are 3-8 cm (1.2-3.1 in) in length, **alternate** along a thin delicate stem, and have barbs on the undersides. Circular, cup-shaped, leafy structures called **ocrea** surround the stem at each **node** where flower buds, late flowers, and **fruits** emerge.

**Flowers:** Small, white, and generally inconspicuous.

**Fruit/Seeds:** Attractive, deep metallic blue, berry-like **fruits** are arranged in clusters with each **fruit** containing a single glossy black or reddish-black hard seed.

**Stems/Roots:** Delicate, thin, reddish stems have curved downward pointing barbs.

## Similar Species

Some native vine species, including native tearthumbs, may be confused with mile-a-minute; however, they lack the equilateral triangle-shaped leaves and the blue berry-like **fruits**.

## Habitat

Mile-a-minute generally colonizes open and disturbed areas along the edges of woods, wetlands, stream banks, roadsides, and uncultivated open fields. It prefers extremely wet environments with poor soil structure and full sunlight, although it will tolerate shade for part of the day.

## Spread

This self-pollinator produces a large number of seeds that can persist in the soil for up to six years. Birds, ants, small mammals, and water are the primary dispersal methods. **Fruits** can remain buoyant in streams or rivers for 7-9 days, allowing mile-a-minute to disperse over long distances.

## Distribution

Native to India and eastern Asia, the first successful population of this vine in the United States was in York, Pennsylvania in the late 1930s. Today Mile-a-minute has spread to all states in the Mid-Atlantic region, as well as Ohio, Kentucky, Massachusetts, and Oregon.



## Environmental Impacts

Mile-a-minute grows rapidly, overtaking shrubs and other native vegetation by reducing their access to sunlight and destroying their stems and branches by its added weight and pressure. It also poses problems for nursery and horticulture crops, Christmas tree farms, and forestry operations.

United States Distribution



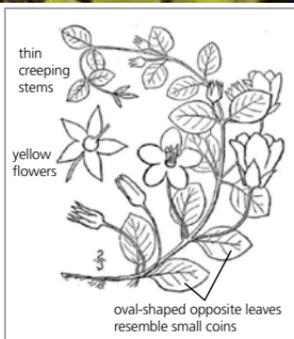
# Moneywort

*Lysimachia nummularia*



## Species at a Glance

Moneywort, also called pennywort and creeping jenny, is an herbaceous low-growing perennial that is part of the primrose family. It forms a thick **creeping** ground cover with stems that can reach up to 0.6 m (2 ft) long and form a mat-like growth about 5-10 cm (2-4 in) tall.



## Identification

**Leaves:** Evergreen to semi-evergreen leaves are simple, **opposite**, and oval in shape, resembling small coins that typically reach 0.6-4 cm (0.25-1.5 in) in length. Upper surfaces of the leaves have widely scattered, glandular, red to black dots.

**Flowers:** Small, cup-shaped, yellow flowers have five petals and small dark reddish to black spots. They are **hermaphroditic** and typically solitary in the leaf **axils**. Blooming usually occurs from June to August, but some may not bloom at all.

**Fruit/Seeds:** Small seeds are located within capsular **fruits** that are about as long as the **sepals**.

**Stems/Roots:** Smooth stems are thin, reddish, and creep along the ground, rooting where the leaf **nodes** come in contact with the soil. The stems branch frequently and often form mats.

## Similar Species

Moneywort is a close relative of yellow pimpernel (*Taenidia integerrima*), which has narrower leaves and smaller flowers with much more pointed petals.

## Habitat

While it can grow in a variety of habitats, moneywort grows best in moist areas like wet meadows, swamps, floodplain forests, stream banks, roadside ditches, and along the banks of small water bodies. It tends to prefer moist, rich, and shaded soils.

## Spread

Moneywort can spread rapidly both by **creeping** stems and seed dispersal. Seeds spread naturally through flood waters; however, they can also be spread through human activities. The extent to which seeds are dispersed by animals is not fully known, but this may be another method of transport.

## Distribution

Introduced from Europe and southwest Asia as early as 1739, moneywort was historically used for ornamental purposes and as a ground cover. It escaped cultivation by 1900 and is now found throughout the United States and can be found in all Mid-western states.



## Environmental Impacts

Little is known about the direct ecological impact of moneywort; however, it has been known to become a nuisance in gardens, pastures, and lawns due to its fast vegetative spread. There is concern that the dense mats formed by this plant could prevent the growth of more desirable native plants.

United States Distribution



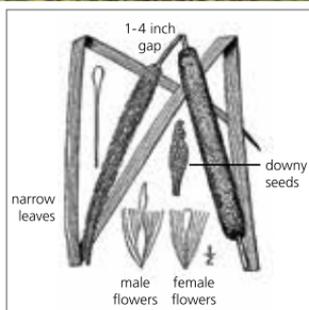
# Narrowleaf & Hybrid Cattails

*Typha angustifolia*, *Typha x glauca*



## Species at a Glance

Cattails are aquatic perennials that grow in wetland areas and produce distinct velvety brown **spikes** of flowers. The two most widespread species in the United States are the native common cattail, also called the broadleaf cattail (*Typha latifolia*), and the non-native narrowleaf cattail (*Typha angustifolia*). The hybrid cattail is produced when these two species cross, giving it characteristics of both species.



## Identification

**Leaves:** Long, narrow (5-15 mm [0.2-0.6 in]), flat leaves originate at the base of the stem from each shoot and spread outward as they rise into the air, reaching 0.9-1.8 m (3-6 ft) in height.

**Flowers:** Dense, fuzzy, cylindrical **spikes** are located at the end of the stem. The flower is divided into two distinct male and female flowers separated by a 3-10 cm (1.2-3.9 in) gap. Lighter brown male flowers (**staminate**) are located above the female (**pistillate**) flowers, which are often green during bloom, turning dark brown during seed maturation.

**Fruit/Seeds:** Cigar-shaped **fruits** about 5-15 cm (2-5.9 in) long contain soft downy seeds about 1 mm (0.04 in) in size.

**Stems/Roots:** The flowering **stalks** are light green, stiff, round in cross-section, and grow up to 3 m (10 ft) tall.

## Similar Species

Both the narrowleaf and hybrid cattails can be easily confused with the native common cattail. The common cattail has both male and female flower types directly next to each other, whereas the invasive cattails have a clear separation of male and female flowers and the leaves are narrower, deeper green, and typically extend beyond the **spike**.

## Habitat

Stands of non-native cattail can be found in a wide variety of wetland habitats, including marshes, lakeshores, river backwaters, and roadside ditches. This prolific plant can grow in disturbed areas as well as brackish and polluted waters of depths nearing 0.9 m (3 ft).

## Spread

The flower head of the parent plant can produce 250,000 seeds, which can remain viable for up to 100 years waiting for the right amount of water and sunlight to germinate. Seeds are dispersed by wind and once established, additional spread occurs through an extensive underground root system.

## Distribution

Narrowleaf cattails are believed to have originated from the dry ballast of European ships on the Atlantic seaboard. The hybrid cattail may occur wherever both the native and the narrow-leaved species are present. These plants have spread throughout the United States, and all three cattail species are found in the Mid-Atlantic region.



## Environmental Impacts

Cattails grow in dense monocultures that can dominate shorelines near open water areas, eliminating habitat and replacing native plants that are important for waterfowl and wildlife. They are also thought to be **allelopathic**, meaning they produce chemicals which prevent the growth of other plant species.

United States Distribution



# Poison Hemlock

*Conium maculatum*



## Species at a Glance

Poison hemlock, also called deadly hemlock and poison parsley, is a weedy plant in the parsley family that is acutely toxic to both people and animals. It has a biennial growth pattern with first year growth forming low-lying **rosettes** of lacy leaves with reddish or spotted stems, followed by extensive growth of 1-3 m (3-10 ft) during the second year.



## Identification

**Leaves:** Bright green, fern-like, shiny leaves are highly dissected and **alternately** arranged on the stem, dividing three to four times. They can reach up to 30 cm (12 in) long and 10 cm (4 in) wide and have a strong musty smell.

**Flowers:** Small, white, five-petaled flowers form in umbrella-shaped clusters in June and July.

**Fruit/Seeds:** Light brown, barrel-shaped seeds are paired, flattened, and 0.3 cm (0.1 in) long with conspicuous longitudinal ribs. They form in green, ridged capsules that eventually turn brown.

**Stems/Roots:** Stout, extensively branched, and erect stems have distinct ridges. They are hollow, except at the **nodes**, and the lower portion of the stems have purple spots. The roots have an odor similar to carrots or parsnips.

## Similar Species

Poison hemlock may be confused with other members of the carrot family that have white umbrella-shaped flower clusters, including Queen Anne's lace (*Daucus carota*) and cow parsnip (*Heracleum L.*). Queen Anne's lace has hairs on the leaves and stems that are not found on poison hemlock. Cow parsnip differs from poison hemlock by its ribbed stem and its **palmately compound leaves**, which radiate at the end of the **stalk** in a semicircle. Neither look-a-likes have purple spotting on the stems.

## Habitat

Poison hemlock grows at low elevations bordering pastures and cropland and gradually invading perennial crops. It can frequently be found in stream and ditch banks, riparian woodlands, and floodplains. It tends to be more competitive in wet soils conditions but can survive in dry sites.

## Spread

Reproducing only by seed, poison hemlock relies on spread primarily through water, birds, animals, and human activity such as agricultural equipment and mowing. Up to 40,000 seeds per plant are produced, which often drop next to the parent plant and regenerate, forming dense stands. Seeds also have a long dispersal period (from September to late February) because the plant **stalks** can persist through winter and seeds can remain viable for up to six years.

## Distribution

A native of Europe, poison hemlock was introduced to North America in the 1800's as a garden and ornamental plant. Since then, it has been extremely successful at distributing itself in nearly every state in the United States and is present in all Mid-Atlantic states.



## Environmental Impacts

Poison hemlock grows aggressively in moist pastures and meadows where it has the potential to outcompete more desirable native species. Early spring growth makes it more likely to be eaten by animals when there is limited forage available. All parts of the plant are highly poisonous and can be fatal to humans and livestock. Symptoms of poisoning can occur in as little as 20 minutes and death can result from respiratory paralysis after ingestion.

United States Distribution



# Policeman's Helmet

*Impatiens glandulifera*



## Species at a Glance

Policeman's helmet, also called ornamental jewelweed and poor man's orchid, is a large, annual, herbaceous plant in the "touch-me-not" family that grows up 3 m (10 ft) tall. The large pink-purple flowers are shaped like an English policeman's helmet or an orchid, giving the plant its common name.



## Identification

**Leaves:** Large oblong or egg-shaped leaves are toothed with a pointed tip. They are either **oppositely** arranged or found **whorled** in groups of three.

**Flowers:** Irregular five-parted flowers arise from the leaf **axils** and are pink to white to purple in color. Flowering occurs from mid-June through October.

**Fruit/Seeds:** Seeds can eject up to 20 feet from mature seed pods when touched or disturbed. They remain viable in the soil for 12-18 months.

**Stems/Roots:** Fleshy, smooth, hollow, reddish stems are multi-branching and resemble bamboo. They have distinct swollen **nodes** that help distinguish it from other plants.

## Similar Species

Policeman's helmet could be mistaken for other members of the same genus such as orange jewelweed (*Impatiens capensis*) and the pale touch-me-not (*Impatiens pallida*). It can be distinguished from these look-a-likes by its pinkish-purple flowers, swollen **nodes**, and **serrated** leaves.

## Habitat

Although it is tolerant of many soil types, policeman's helmet must have high moisture content such as the soils found in wetlands, riparian areas, moist woodlands, gardens, and parks. It tends to thrive in partial shade, but can also be found growing in full sun.

## Spread

Reproducing entirely by seeds, policeman's helmet can produce up to 800 seeds per plant that have long viability and high germination rates. Seeds can float and germinate in the water, allowing the plant to move down waterways into new areas.

## Distribution

Native to the western Himalayas, policeman's helmet was probably introduced into the United States as a garden ornamental. In Britain, it is considered extremely invasive and is one of the "top 20" non-native weeds. In the Mid-Atlantic region, this species is found in New York.



## Environmental Impacts

Policeman's helmet is a highly aggressive invader that forms dense colonies that displace native and beneficial plants, reduce forest regeneration, and contribute to flooding and erosion by changing or stopping water movement. Because it is an annual, it dies down in the winter, leaving no food or habitat for wildlife.

United States Distribution



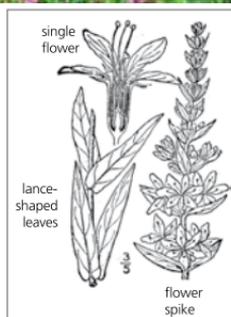
# Purple Loosestrife

*Lythrum salicaria*



## Species at a Glance

Purple loosestrife is an upright perennial herb that can grow 0.9-3 m (3-10 ft) high depending on environmental conditions. While gardeners may enjoy the brilliant purple display, its attractiveness doesn't outweigh the serious threat it poses to ecosystems in the Mid-Atlantic.



## Identification

**Leaves:** The body of the leaf is lance-shaped or oblong while the base is usually heart-shaped or rounded. Leaves are **stalkless** with smooth edges and are sometimes covered in fine, downy hairs. They reach 4-10 cm (1.6-3.9 in) in length and are usually paired and **opposite** each other down the stem, but can also be **whorled** in groups of three.

**Flowers:** Paired or clustered into 10-40 cm (3.9-16 in) long magenta colored **spikes**. Each flower is complete, containing 5-7 petals that can range in color from pink to purple-red and blooms from June to September.

**Fruit/Seeds:** Two valve-shaped capsules burst at maturity, releasing seeds in late July or August.

**Stems/Roots:** Mature plants can have 1-50 square, woody stems arising from a large central taproot. Stems are 4-6 sided, green to purple in color, and are often branching, giving the plant a bushy or woody appearance.

## Similar Species

It's best to identify purple loosestrife during its long period of bloom when the characteristic reddish-purple flower masses can be easily seen. It is often confused with blue vervain (*Verbena hastata*), which has toothed instead of smooth leaves; blazing star (*Liatris spp.*), which only has one flowering **stalk**; and other species of loosestrifes.

## Habitat

Purple loosestrife occurs in freshwater and brackish wetlands, riparian corridors, ditches, and other moist soil areas. It is a successful colonizer and potential invader of any wet, disturbed site in North America.

## Spread

A long flowering season allows purple loosestrife to produce an estimated two to three million seeds per year from its 30-50 flowering stems. It can also reproduce **vegetatively** through underground stems at a rate of about 0.3 m (1 ft) per year.

## Distribution

Native to areas of Europe and Asia, purple loosestrife was brought to North America in the early 1800s for ornamental and medicinal uses. It has since spread to almost every state in the U.S. and is widespread in all Mid-Atlantic states.



## Environmental Impacts

Purple loosestrife quickly establishes and spreads, outcompeting and replacing native grasses and other flowering plants that provide high-quality food and habitat sources for wildlife. It forms dense stands that restrict native wetland plants and alter the structural and ecological values of wetlands.

United States Distribution



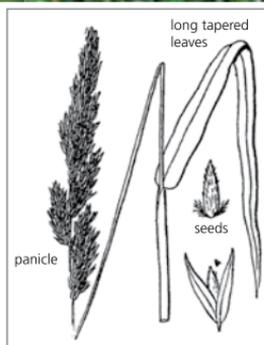
# Reed Canary Grass

*Phalaris arundinacea*



## Species at a Glance

Reed canary grass is a large cool-season perennial that grows 0.6-2.7 m (2-9 ft) in height and forms large **monotypic** stands that can dominate an area. Two virtually indistinguishable ecotypes are thought to exist in the United States, including a native ecotype and a more aggressive Eurasian one.



## Identification

**Leaves:** Long, gradually tapering leaves have flat blades that have a rough texture on both the upper and lower surfaces. Size ranges from 9-25 cm (3.5-9.8 in) long and 0.5-2 cm (0.2-0.8 in) wide. Coloration can be light green to a straw color. A transparent, thin, membranous outgrowth called a **ligule** is also present at the junction of the leaf and **stalk**.

**Flowers:** Densely packed clusters called **panicles** are generally 7.5-15 cm (3-5.9 in) in length and arise from the stem high above the leaves from May to mid-June. At first, they appear a green to purple color but gradually change to beige over time.

**Stems/Roots:** Sturdy, often hollow, hairless stems are 1 cm (0.4 in) in diameter and have some reddish coloration near the top.

## Similar Species

The highly transparent **ligule** is helpful in distinguishing reed canary grass from the non-native orchard grass (*Dactylis glomerata*), which has leaves with wider blades, and more narrow and pointed clusters of flowers. Additionally, bluejoint grass (*Calamagrostis canadensis*) may be mistaken for reed canary grass in areas where orchard grass is rare.

## Habitat

A wetland plant, this species typically occurs in soils that are saturated for most of the growing season but where standing water does not persist for extended periods. Ideal conditions typically occur in roadside ditches, rights-of-ways, river dikes, levees, shallow marshes, and meadows.

## Spread

Seeds and **creeping rhizomes** help reed canary grass spread aggressively. Seeds can be moved from one wetland to another by waterways, animals, humans, or machines.

## Distribution

Reed canary grass is native to temperate regions of Europe, Asia, and North America. Historically, the Eurasian ecotype was planted throughout the United States for forage and erosion control. It has become naturalized in much of the northern half of the United States and is widespread throughout the Mid-Atlantic region.



Thin, membranous ligule at junction of leaf and leaf stalk.

## Environmental Impacts

Reed canary grass forms large **monotypic** stands that harbor few other plant species and are of little use to wildlife. Once established, it dominates an area by building up a seed bank that can eventually erupt, germinate, and recolonize treated sites.



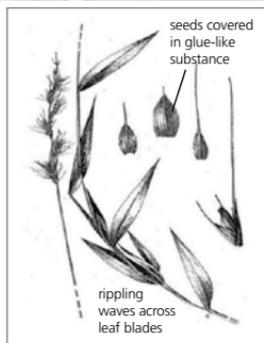
# Wavyleaf Basketgrass

*Opismenus hirtellus* spp. *Undulatifolius*



## Species at a Glance

Wavyleaf basketgrass is an introduced subspecies of the native basketgrass (*O. hirtellus* (L.) P. Beauv.). It is a fast-spreading, perennial, understory grass that forms dense stands that can crowd out native herbaceous plants and threaten the **deciduous** forests of eastern North America.



## Identification

**Leaves:** Flat, dark green leaves are about 1.2 cm (0.5 in) wide and 4-10 cm (1.5-4 in) long with rippling waves across the blades and elongated, pointed tips. The leaf **sheaths** and stems are noticeably hairy.

**Fruit/Seeds:** Seeds, which begin to appear in late summer, are covered with a glue-like substance that allows them to stick to other objects and organisms.

**Stems/Roots:** Stems are branching and covered in fuzzy hairs. Rooting occurs at the **nodes** of the stems.

## Similar Species

While wavyleaf basketgrass resembles Japanese stilt grass (*Microstegium vimineum*), these species differ in that the leaves of Japanese stiltgrass have a silvery row of hairs running down the **midvein** and end in a blunt gradual point. Wavyleaf basketgrass leaves are rippled across their width and end with an elongated sharp tip.

## Habitat

Wavyleaf basketgrass is a shade tolerant species that avoids sunny environments. It is mainly found in shaded, moist, **deciduous** forests.

## Spread

Wavyleaf basketgrass spreads quickly through **rhizomes** and seeds. The sticky substance on the seeds allows them to adhere to passing animals, people, or vehicles, easily spreading to new locations.

## Distribution

Native to Europe and Asia, it's unclear how wavyleaf basketgrass was first introduced to the United States; however, it's possible it was through contamination of hanging baskets. It was first found in Howard County Maryland in 1996. In 2000, it was found growing along a stream in Baltimore County, Maryland. Documented locations have also been found in Virginia.



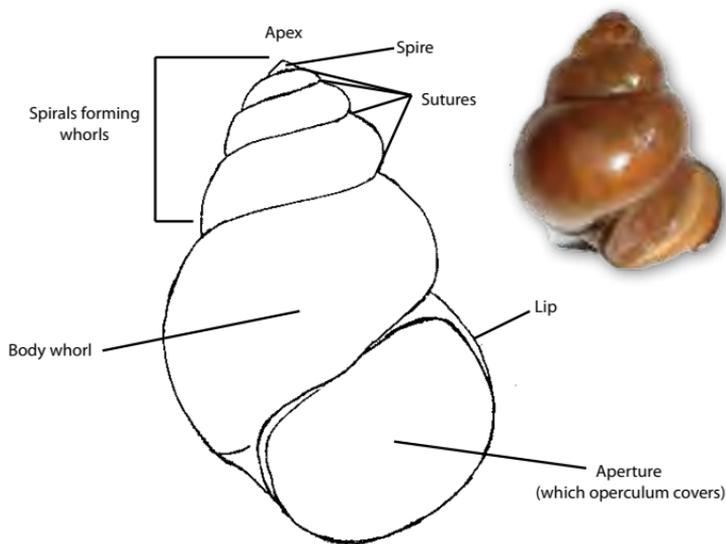
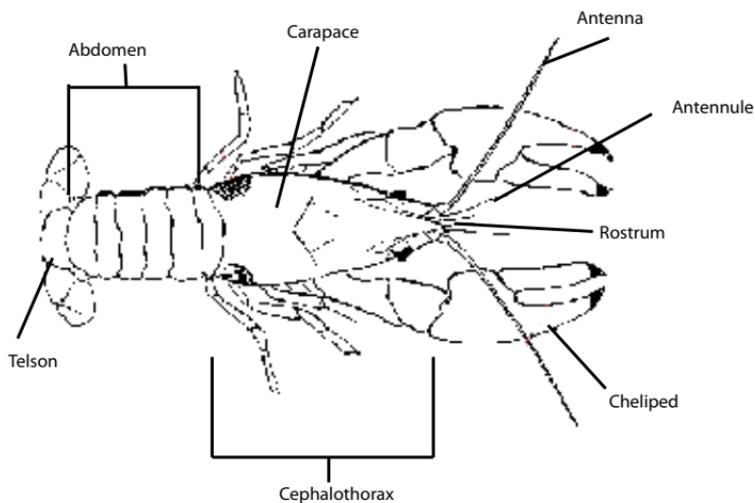
## Environmental Impacts

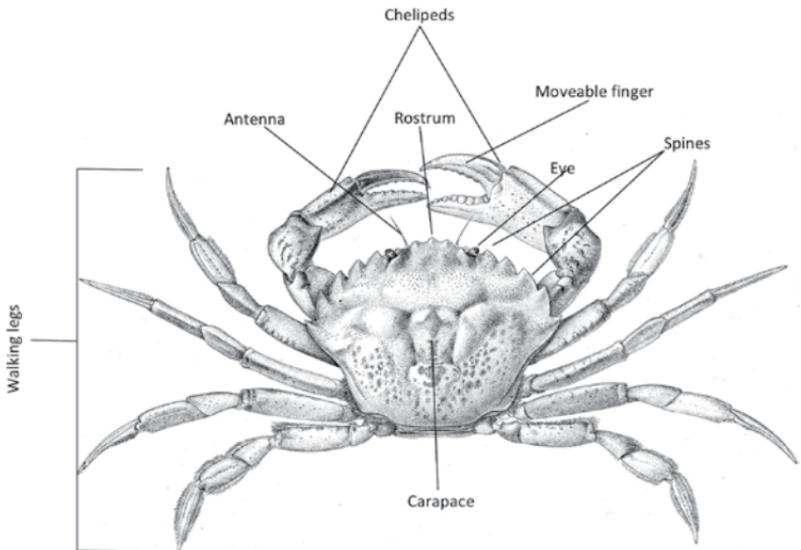
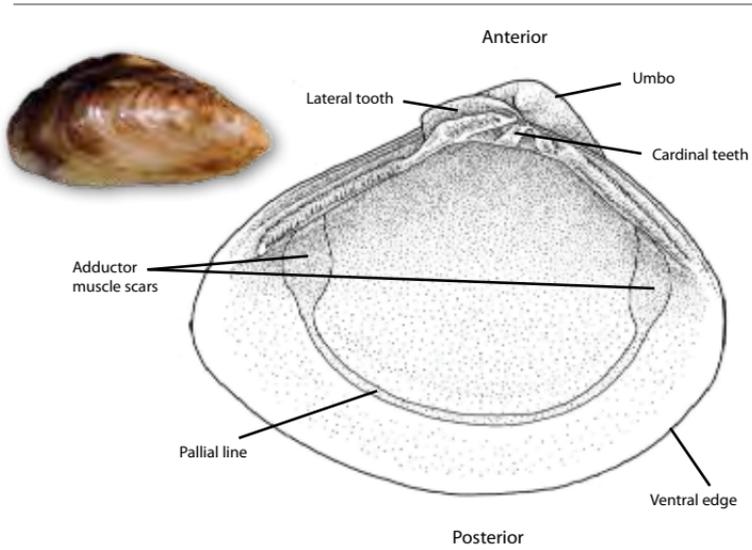
This species can completely cover the forest floor, providing competition against native forest species. With the decrease in plant diversity, wavyleaf basketgrass also provides very little wildlife value. Because it is still relatively new in the United States, its ecological impacts are mostly unknown.

United States Distribution



# Invertebrate Anatomy





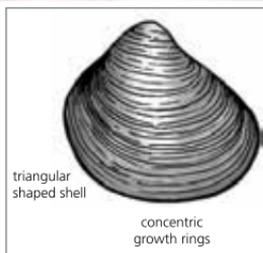
# Asian Clam

*Corbicula fluminea*



## Species at a Glance

The Asian clam, also called the Asiatic clam, pygmy clam, or gold clam, is a small fresh-water bivalve with two thick-hinged shells that rarely exceeds the size of a quarter. It was first introduced to the west coast of the United States in 1924, possibly as a food item. By the 1970s, it occupied most of the Mississippi River Basin, the Gulf Coast, and the eastern United States.



## Identification

The shell is typically yellow-green to brown; however, darker **morphs** exist, usually in the southwestern United States. While the small shell averages 2.5 cm (1 in), it can reach up to 6.5 cm (2.6 in) long. The shell is thick, rounded to slightly triangular in shape, and displays elevated, concentric growth rings. The inside of the shell is layered with white to light purple polished **nacre** and the teeth are finely **serrated**. Microscopic juveniles called **veligers** appear under a microscope in a "D"-shape less than 1 mm (0.04 in) in length.

## Similar Species

Fingernail and pea clams have smooth, instead of **serrated**, teeth and are generally smaller, with thinner shells and less prominent growth rings. There is also evidence that there may be other invasive species of *Corbicula* (*C. largillierti*, and *C.* species unknown) in Illinois; however, it is unknown whether these species are present in the Mid-Atlantic, and suspected populations should be reported. *C. largillierti* is dark olive-brown, has as a pyramidal-shaped shell, lateral purple teeth, and the ridges are tighter and less pronounced than *C. fluminea*. The unknown Asian clam species has a yellow, triangular shell with fine pinkish-rust colored rays radiating from the **umbo**.

## Habitat

The Asian clam prefers running water with a sand or gravel substrate. It can be found in streams, rivers, ponds, lakes, and man-made canals. Although it is a freshwater species, it can withstand slightly brackish waters and is also tolerant of degraded waters.

## Spread

Because it is **hermaphroditic**, the Asian clam is capable of self-fertilization. In warmer waters, it can spawn year round, and a single clam can release hundreds to thousands of free-floating, microscopic **veligers** per day. Juveniles are then spread by water currents and human activity. The Asian clam attaches to boating, fishing, and scuba diving equipment, and **veligers** can be transferred in bait buckets or live wells.

## Distribution

While native to the temperate and tropical regions of Asia and Africa, the Asian clam is widespread in the United States and spans every state in the Mid-Atlantic region.



## Impacts

The Asian clam is a known **biofouler** that blocks water flow to power plants and industrial water systems, and causes problems in irrigation canals and pipes. It also increases clarity in the water column by filtering suspended matter, leading to excessive plant growth and altered nutrient and water quality. This clam may also compete with native mollusks for food and habitat.

United States Distribution



# Asian Shore Crab

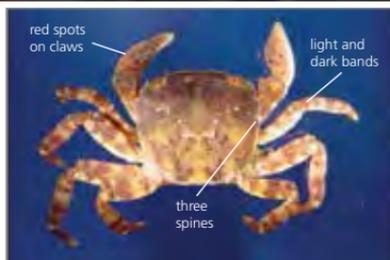
*Hemigrapsus sanguineus*



## Species at a Glance

The Asian shore crab, also called the Japanese shore crab, is a small species of crab from the Asia-Pacific region. It has a very broad diet and

has the potential to affect populations of native species, such as crabs, fish, and shellfish in its introduced range. It may also compete with larger species, like the blue crab, rock crab, and even invasive green crabs.



## Identification

The Asian shore crab is small, with adults ranging from 35 mm (1.5 in) to 42 mm (1.65 in) in **carapace** width. It has a square-shaped shell with three spines on each side of the **carapace**. **Carapace** color can be green, purple, orange, brown, or red. It has light and dark bands along its legs and red spots on its claws. Male crabs have a distinctive, fleshy, bulb-like structure at the base of the moveable finger on the claws.

## Similar Species

The Asian shore crab may be confused with other species of crab, such as the green crab (*Carcinus maenas*); however, the green crab is larger and has five points on the **carapace** instead of three.

## Habitat

A very versatile crab, the Asian shore crab can tolerate a wide range of temperature and salinity ranges, inhabiting any shallow hard-bottom intertidal or sometimes subtidal habitat. It can live on artificial structures and on mussel beds and oyster reefs. It also tends to aggregate at high densities under rocks where its habitat can overlap with native crab species.

## Spread

It is unknown how this species was introduced to the United States, although many speculate that both adults and larvae were introduced through ballast water discharges from transoceanic ships. It is highly prolific, with females producing 50,000 eggs per clutch, and 3-4 clutches per breeding season. The larvae are suspended in the water for approximately one month before developing into juvenile crabs, allowing them to be transported over great distances to new locations.

## Distribution

Native to the coasts of China, Hong Kong, Korea, Russia, and Japan, the Asian shore crab was first reported in the United States at Townsend Inlet in New Jersey in 1988. It is now well established along the Atlantic intertidal coastline of the United States from Maine to North Carolina. Because it is tolerant of a wide range of environmental conditions, it is likely that its spread will continue along the U.S. coastline.



## Impacts

Because it has a very broad diet, the Asian shore crab has the potential to affect native populations by disrupting the food web. It has also been known to feed on commercially important species, such as larval lobsters, crabs, fish, and shellfish. Trends are showing the numbers of shore crabs are steadily increasing, while native crab populations are decreasing because they occupy habitats very similar to the native crabs. The Asian shore crab may also pose a threat to coastline ecosystems and aquaculture operations.



# Australian Spotted Jellyfish

*Phyllorhiza punctata*



## Species at a Glance

The Australian spotted jellyfish, also known as the floating bell, was introduced to North America from the Western Pacific Ocean. It is threatening large commercial fisheries in the Gulf of Mexico by feeding on the eggs and larvae of fish, crabs, and shrimp, and by clogging fishing nets. While mildly venomous, it does not pose a threat to humans who may come in contact with it.



## Identification

Large with a somewhat flattened gelatinous bell that is clear or possibly tinted brown with many small white crystalline refractive spots close to the surface. The bell is usually 45-50 cm (18-20 in) in diameter, but there has been a maximum reported size of 62 cm (24 in) and a weight of 11 kg (25 lbs). The bell **margin** lacks tentacles and the central mouth area is ringed by eight, thick, highly branching oral arms that end with large brown bundles of stinging cells. From each oral arm hangs a long ribbon-like transparent appendage. Within its native range, and in certain introduced localities, the jellyfish is a deep brown color owing to the presence of symbiotic **protozoans** called **zooxanthellae**; however, the Gulf of Mexico populations do not host the **zooxanthellae** and lack the brown coloration.

## Similar Species

This species may be confused with the moon jellyfish (*Aurelia aurita*) based on similar size, but the moon jelly can be easily distinguished by its transparent body and horseshoe-shaped gonads, which can be easily seen through the top of the bell. In other parts of the world, the Australian spotted jellyfish co-occurs with other **mastigiid** jellyfish, which are similar in appearance, including several species belonging to the genus *Mastigias*.

## Habitat

This coastal and estuarine jellyfish prefers warm temperate seas and is often aggregated in near-shore waters, swimming near the surface in murky waters of harbors and embayments.

## Spread

While it's unclear how the Australian spotted jellyfish was introduced from Australia, many believe that ship traffic brought the jellyfish to the Gulf of Mexico. Once introduced, natural ocean circulation processes further distributed it. For example, specimens were able to break off the Loop Current that circulates through the Gulf and individuals ended up in an eddy south of the Alabama and Florida panhandle.

## Distribution

The Australian spotted jellyfish has a wide native distribution in Australia and much of the Indo-Pacific, including the Philippines archipelago. Swarms of this jellyfish have been reported from east Texas to Florida in the Gulf of Mexico and along the Atlantic coastlines of Florida, South Carolina, and North Carolina.



## Impacts

This jellyfish threatens large commercial fisheries of shrimp and crab in the Gulf of Mexico. It is feared it will feed directly on the eggs and larvae of fish, crab, and shrimp, having serious economic implications for commercial fishing. One of its biggest economic impacts has been the clogging of shrimp nets, which has an estimated economic loss ranging in the millions of dollars. The Australian spotted jellyfish also damages boat intakes and fishing gear, and has caused the closure of productive areas to fishing activities.

United States Distribution



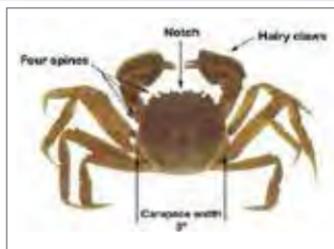
# Chinese Mitten Crab

*Eriocheir sinensis*



## Species at a Glance

The Chinese mitten crab is a medium-sized burrowing crab from East Asia. It made its way to the United States in parts of San Francisco, the Great Lakes region, and the Mid-Atlantic region. It can tolerate both fresh and salt water, and its aggressive nature has allowed it to become a costly and environmentally damaging invader in these areas.



## Identification

Size of the Chinese mitten crab ranges from 30-100 mm (1.2-4 in), with legs about double the length of the torso. It gets the name “mitten crab” from the dense patches of hairs covering the claws, resembling mittens. These hairs are more common in males than females, and juveniles may not have any hair. The tips of the claws are typically white. Four pairs of spines are located on the side edges of the **carapace**. Color ranges from a light brownish-orange to a greenish-brown. There is also a small notch present between the eyes.

## Similar Species

None.

## Habitat

While the Chinese mitten crab is the only crab found in the fresh waters of the United States, it can also tolerate salt water. This crab is very skillful at walking on land, especially during upstream migration, allowing it to bypass dams and other natural obstructions.

## Spread

The Chinese mitten crab has most likely spread in the ballast water of ships and as it clings to the hulls of barges during transport. It is becoming popular in the seafood market, especially in New York, and may have been released by purchasers into new areas.

## Distribution

This species was first identified in eastern Asia and subsequently spread throughout Europe. It was discovered in the United States in 1962 in the Great Lakes and has since been reported along the Gulf Coast, San Francisco Bay, Chesapeake Bay, the Hudson River, and other East Coast areas.



## Impacts

The burrowing behavior of the Chinese mitten crab causes erosion of stream banks and damage to embankments, as well as clogged drainage systems. It is also becoming a nuisance for recreational and commercial anglers when it becomes tangled up in nets.

One positive aspect of this crab is that it can be a food source for predatory fish.



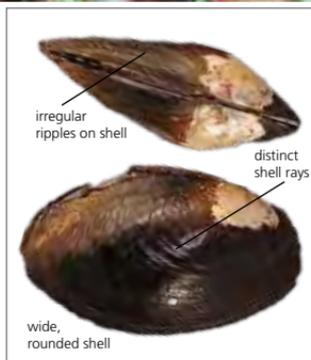
# Chinese Pond Mussel

*Sinanodonta woodiana*



## Species at a Glance

The Chinese pond mussel, also called the Eastern Asiatic clam, or swan-mussel, is a large, invasive, freshwater mussel that has rapidly spread to colonize Europe, Central America, the Indonesian Islands, and most recently, North America. Its life cycle involves a larval parasitic stage on freshwater fish, which helps contribute to its spread.



## Identification

The large, wide shell reaches a maximum size of 30 cm (12 in). It has a deeply rounded **ventral margin** and the surface is irregularly rippled. The thin coating on the outside of the shell (**periostracum**) is brown, showing distinct shell rays that run perpendicular to growth lines. The **nacre** (inner shell surface) has a wide, pink band along the outer edge.

## Similar Species

The native alewife floater (*Anodonta implicata*) is often confused with the Chinese pond mussel; however, in the alewife floater the **periostracum** color is variable, shell rays often are not visible in older individuals, and the **nacre** doesn't have a pink band. In addition, alewife floaters only reach a maximum shell size of 18 cm (7 in). Identification of these mussels is difficult and often requires expert verification.

## Habitat

A habitat generalist, the Chinese pond mussel is able to tolerate environmental conditions considered unsuitable for native mussels, such as degraded and polluted habitats, heavily modified and artificial habitats, low oxygen conditions, and areas with high siltation rates. It prefers silt and clay substrates and **turbid** conditions with relatively high water temperatures in either standing or slow-flowing water.

## Spread

The life cycle of the Chinese pond mussel includes a parasitic larval stage, where it lives for a short time attached to the fins or gills of freshwater fish species. Natural movement of the host fish, or the export of this mussel between regions for aquaculture and the live food trade has allowed it to spread to new locations and establish. It is prolific and begins reproducing within its first year of life.

## Distribution

Native to Eastern Asia, primarily from the Amur and Yangtze rivers, the Chinese pond mussel's first and only documented occurrence in the United States has been in the ponds of a former fish farm in Franklin Township, New Jersey. It is considered locally established in these ponds, and was most likely introduced in the larval stage attached to the gills of imported Asian carp.



## Impacts

While its impact in the United States is currently unknown, the Chinese pond mussel could negatively impact native mussel populations as it outcompetes them for host fish during the larval stage. In addition, it may have a negative impact on macroinvertebrates communities and the overall structure of aquatic ecosystems.



# Faucet Snail

*Bithynia tentaculata*



## Species at a Glance

The faucet snail is an aquatic snail native to Europe that threatens waterfowl, food webs, and can clog water intakes. It can quickly spread to inland waters, often reaching high densities and outcompeting native snails.

## Identification

The shell is shiny, oval in shape, and ranges from light brown to black in color. The **spire** is relatively large and rounded, consisting of 5-6 somewhat flattened **whorls**. Adults can grow up to 12-15 mm (0.5 in) in length, but are generally smaller. A tough plate called the **operculum** tightly covers the shell opening (**aperture**). It is teardrop-shaped and displays concentric rings on adults. The **aperture** is on the right side when the shell is pointed up, and is less than half the height of the shell.



## Similar Species

Native snails and young nonnative mystery snails can look similar to the faucet snail and can be difficult for non-experts to identify conclusively.

## Habitat

Commonly found in freshwater ponds, shallow lakes, and canals, the faucet snail attaches to objects in the water. It prefers gravel, sand, clay, mud, or the undersides of rocks as substrate in the fall and winter, and aquatic plants in warmer months. It can be found in depths of up to 5 m (16 ft).

## Spread

This snail can spread by attaching to aquatic plants, waterfowl, boats, anchors, other recreational gear, and equipment placed in the water. It can also live in the water of livewells, bait buckets, and bilges. The faucet snail can live for up to one month in dry mud, so proper cleaning of equipment is essential before moving to a new water body.

## Distribution

Native to Europe, the faucet snail was introduced to the Great Lakes in the 1870s. It was most likely brought to North America unintentionally in the solid ballast of larger timber transport ships or in vegetation used in packing crates. In the Mid-Atlantic, this snail is established in New York, Pennsylvania, Maryland, Virginia, and Washington DC.



## Impacts

The faucet snail competes with native snails for food and resources and can clog water intake pipes and screens in municipal water systems. It is also an intermediate host for three intestinal trematode parasites that can kill waterfowl. These parasites do not pose a risk to humans consuming cooked fish or waterfowl.



# Golden Mussel

*Limnoperna fortunei*



## Species at a Glance

While not yet found in North America, researchers predict that the golden mussel could colonize areas in North America where zebra and quagga mussels could not. It is often referred to as an “ecosystem engineer”, due to its ability to rapidly alter aquatic ecosystems.



## Identification

The shell of the golden mussel is dark brown above the **keel** and yellow to golden brown below. The interior **nacre** of the shell is purple above the **keel** and white below. Average shell length is 20 mm (0.8 in), although certain South American populations have reached up to 40 mm (1.5 in) and certain Asian populations have reached up to 60 mm (2.4 in). Females typically compose two-thirds of the population.

## Similar Species

The golden mussel is similar to the zebra mussel (*Dreissena polymorpha*) and quagga mussel (*Dreissena bugensis*). A distinctive characteristic of the golden mussel is the presence of a **nacreous** layer within the shell. Although these mussels share some of the same physical characteristics, the golden mussel exhibits a wider tolerance of ecological conditions than both Dreissenid mussels; therefore, if introduced into North American waters, the golden mussel is expected to invade a broader range of habitats.

## Habitat

While it can acclimate itself to many types of environments, the golden mussel prefers brackish to freshwater lakes, rivers, and estuaries between 8-32°C (46-89°F). It uses sticky **byssal threads** to attach itself to hard substrates such as rocks, docks, logs, pilings, and other organisms. This species is tolerant of polluted and contaminated water conditions.

## Spread

The golden mussel was most likely introduced to South America in the ballast water of ships, or as a contaminant in shipments of live Asian clams. Once introduced, golden mussels reproduce frequently after they reach maturity at one year of age. The larvae can be transported in bait buckets, live wells, bilges, or in ballast water. Adults may attach to boats, trailers, equipment, and aquatic plants and be moved to new locations.

## Distribution

Native to China, and southeastern Asia, the golden mussel was introduced into Argentina in 1991. Within a decade, it spread to four other South American countries. Although it has not yet been detected in North America, it is predicted to be a future threat.



## Impacts

The golden mussel settles in high numbers on native **bivalves**, causing them to suffocate or starve. It has similar impacts to zebra and quagga mussels, reproducing frequently and in large numbers, fouling water intakes pipes, and damaging equipment. By filter feeding, it also alters water quality and decreases food sources for native species. Communities in South America estimate a cost of \$200,000 per day in industrial and ecological losses.



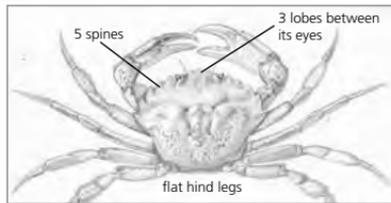
# Green Crab

*Carcinus maenas*



## Species at a Glance

One of the world's most successful invaders, the green crab is a voracious predator from Europe that feeds on shellfish, causing declines of other crabs and **bivalve** species. It is capable of learning, and can improve its prey-handling skills while foraging.



## Identification

Despite its name, the green crab is not always green, but can be mottled dark brown to dark green on the top shell (**carapace**) with small yellow patches. The underside of the shell may change from green to orange and then red during the molting cycle. It has an array of five spines on either side of the eyes on the front end of the **carapace**. It also has three rounded lobes or bumps present between its eyes. Adult crabs are typically 6 cm (2.5 in) long, but can range up to 10 cm (4 in). The last pair of hind walking legs are relatively flat, similar to those of a Dungeness crab.

## Similar Species

While it may be confused with other native crab species, the green crab can be distinguished by the array of five spines on either side of the eyes, as well as the three lobes between the eyes.

## Habitat

Found in a variety of habitats, the green crab can tolerate a wide range of environmental conditions including salinity and temperature fluctuations. It is also found to inhabit protected rocky shores, cobble beaches, sand flats, and tidal marshes.

## Spread

The green crab was most likely introduced through ballast water and shipping; however, it may have also arrived hidden in kelp packing material used in live lobster and bait worm shipments. Once established, the green crab has a floating larval stage that allows it to expand its distribution to new locations on water currents.

## Distribution

Native to the Atlantic coast of Europe and northern Africa, the green crab first arrived in the Cape Cod region of the United States in the mid-1800s via sailing ships. It began its northward expansion along the Atlantic coast in the early 1900s and was discovered on the West Coast in 1989. Today, the green crab is found throughout the coast of the Mid-Atlantic region from North Carolina northward.



## Impacts

The green crab threatens populations of crabs, clams, mussels and oysters through competition, predation, and its burrowing activities. It has contributed to the decline of many valuable economic commercial species, such as soft shell crabs on the East Coast and Dungeness crabs on the West Coast. This voracious predator can consume 40 half-inch clams per day, as well as crabs its own size.

United States Distribution



# Marbled Crayfish

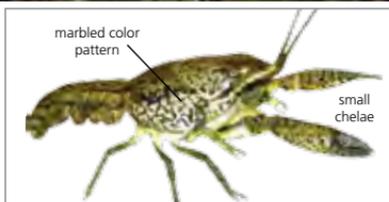
*Procambarus fallax f. virginalis*



## Species at a Glance

The marbled crayfish, also called the marmorkreb (which is German for “marbled crayfish”), is a **parthenogenetic** female

crayfish thought to be a form of the slough crayfish (*Procambarus fallax*). Therefore, it has been designated an informal subspecies, although some researchers have proposed a new species designation, *Procambarus virginalis*. There are no known native populations of this crayfish, and the only known cases of it in the wild are where it has been introduced by humans.



## Identification

This medium-sized crayfish has a distinct marbled color pattern and a small pincer-like claw called a **chelae**. Coloration can differ depending on its diet, occasionally showing blues or greens. The total length is up to 13 cm (5 in), but it is more often found less than 10 cm (4 in). The upper side of the **carapace** is smooth, while the sides are slightly granulated.

## Similar Species

The marbled crayfish is closely related to the slough crayfish (*Procambarus fallax*), which is widely distributed across Florida and has similar coloration and general appearance. Distinguishing these species can be difficult because only female marbled crayfish exist, making it difficult to use identification keys that rely on characteristics of the male **gonopods**.

## Habitat

Since there are no indigenous populations of the marbled crayfish, its habitat requirements are often assumed from its closest relative, the slough crayfish. This crayfish can occur in streams and rivers, but seems to prefer still or slow-flowing habitats and is typically found in marshes, wet prairies, and sloughs with lightweight organic soils. It also inhabits temporary wetlands where it can retreat into burrows during dry periods.

## Spread

Spread of the marbled crayfish through the pet trade increases the probability of it being released into natural ecosystems. It is the only known **decapod** crustacean species to reproduce through **parthenogenesis**, and therefore, all individuals are female and only one is needed to establish a new population. Because each crayfish is genetically identical, easy to care for, and has high reproductive rates, it is also popular in labs as a model organism for studying development.

## Distribution

The marbled crayfish was discovered in Europe in the 1990s. It has since been introduced to multiple countries on three continents, including Germany, Sweden, Hungary, the Netherlands, Italy, Slovakia, Madagascar, and Japan. While some believe the marbled crayfish originates from the southeastern United States, indigenous populations have never been reported and there are no confirmed introduced populations of this species in the United States.



## Impacts

Because of its high reproductive rate and the need for only one individual to start a population, this species is considered a serious future threat to aquatic biodiversity in regions where it becomes established. It is a voracious feeder and consumes a broad range of aquatic plants and invertebrates, putting it in competition with native aquatic flora and fauna.



# Mystery Snails

(Species of the genus *Cipangopaludina*)



## Species at a Glance

Chinese and Japanese mystery snails are large freshwater snails commonly sold for use in freshwater aquariums and garden ponds.

Their popularity in the aquarium industry has contributed highly to their spread across the United States, allowing them to form dense populations and outcompete native species for food and habitat.

## Identification

Both species have a large shell reaching 6.5 cm (2.6 in) in height. It is smooth, strong, and spherical with 6-8 convex **whorls** in the Chinese mystery snail and 7-8 **whorls** in the Japanese mystery snail, which are separated by highly-indented **sutures**. The shell of the Japanese mystery snail grows **allometrically**, with the height increasing faster than the width, making it appear more elongate and narrow than the Chinese mystery snail. Coloration is usually dark olive-green for adults and lighter for juveniles. Some adults are greenish-brown, brown, or reddish-brown. The outer lip of the shell is round or oval-shaped and black. An oblong-shaped **operculum** (or “trap door”) displays concentric growth rings and allows the snail to close the opening of the shell when water conditions are unfavorable or when predators attack. These two snails are often confused with each other, and many consider them the same species.

## Similar Species

The native brown mystery snail (*Cameloma decisum*) has a width to height ratio smaller than both the invasive mystery snails, making it much smaller and narrower with less convex **whorls**. The introduced banded mystery snail (*Viviparus georgianus*) is generally smaller (up to 3.5 cm [1.4 in] in height) and has prominent dark horizontal bands.

## Habitat

These invasive snails inhabit shallow quiet waters of lakes, ponds, marshes, irrigation ditches, rivers, and slower portions of streams with some vegetation and muddy or sandy substrate.

## Spread

Introduction of these snails probably occurred through the aquarium industry and importation for Asian food markets. Once in a body of water, they can be spread by recreational water activities, bait buckets, and water holding areas on boats.

## Distribution

While native to Asia, the Chinese and Japanese mystery snails were introduced to the United States in the 1800s and into the Great Lakes basin in the 1930-40s. They now occur throughout the United States and can be found in all Mid-Atlantic states.



## Impacts

Invasive mystery snails can serve as vectors for transmitting parasites and diseases, and are a known host for some parasites that can infect humans. They can also clog water intake pipes and compete with native snails for food and resources.

United States Distribution



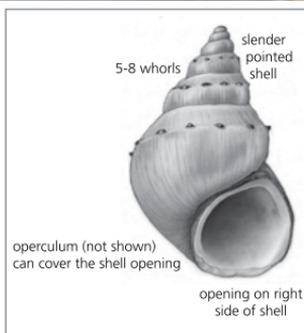
# New Zealand Mudsnail

*Potamopyrgus antipodarum*



## Species at a Glance

The New Zealand mudsnail is a tiny aquatic snail that multiplies quickly and disrupts the food chain. Its small size makes it easy for anglers and boaters to unknowingly transport it from one body of water to another, and since it reproduces **asexually**, it takes only one snail to start a new population.



## Identification

The shell is long, narrow, and coiled to the right in up to eight **whorls** that come to a point at the top of the shell. Each **whorl** is separated by deep grooves. Some **morphs**, such as those in the Great Lakes, can have either smooth shells or shells with a **keel** in the middle of each **whorl**. Average adult size in an invasive population is only 3-6 mm (0.1-0.2 in). Color varies from gray to light and dark shades of brown. An ear-shaped **operculum** covers the opening of the shell.

## Similar Species

While it can resemble many different species of native snail, the New Zealand mudsnail is usually more narrow, longer, and has more **whorls** than most native snails in the same genus.

## Habitat

The New Zealand mudsnail is known to inhabit freshwater ponds, streams, rivers, lagoons, lakes, ditches, and reservoirs. It has a wide range of tolerances for substrate, temperature, and salinity, and can survive in brackish water.

## Spread

The **operculum**, which is a small cover that can be used to close the opening of the shell, allows the New Zealand mudsnail to survive out of water and hitchhike on recreational boating or fishing equipment, the feet of wildlife, feathers, and fur. It can also pass through the digestive system of predators alive and undigested.

## Distribution

While native to New Zealand, this mudsnail was accidentally introduced into the United States in the 1980s, possibly with the transfer of fish eggs and live game fish, or in the ballast water of transoceanic ships. The only occurrences in the Mid-Atlantic region are in New York and Pennsylvania.



## Impacts

The New Zealand mudsnail reproduces rapidly, displacing native species of mollusks and invertebrates, altering the food web, and impacting food sources for native trout and other fish, while offering them little nutritional value in return. It also impacts water by altering natural cycles, such as the nitrogen cycle.

United States Distribution



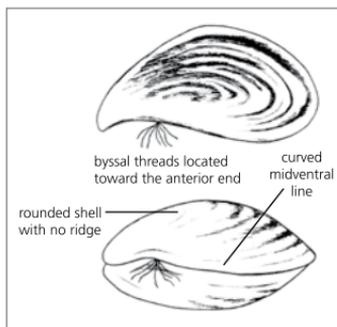
# Quagga Mussel

*Dreissena bugensis*



## Species at a Glance

The quagga mussel is a small, fingernail-sized, freshwater mollusk considered one of the most intrusive, prolific, and costly aquatic invaders in North America. Some feel this species is even more harmful than its close relative the zebra mussel (*Dreissena polymorpha*).



## Identification

The shell is rounded, fan-shaped, and attached by a hinge. It is smooth and lacks ridges, although it typically has dark concentric rings that fade to a pale coloration near the hinge. While usually 3 cm (1.2 in) long, some individuals can reach up to 5 cm (2 in). The sticky thread-like projections called **byssal threads** are located toward the **anterior** end of the shell and help it to attach to other objects. Eggs hatch into round, microscopic larvae called **veligers** that free-float in the water column for up to five weeks before settling.



# Red Swamp Crayfish

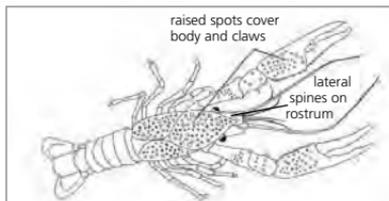
*Procambarus clarkii*



## Species at a Glance

The red swamp crayfish, also known as the red swamp crawfish, Louisiana crawfish, or mudbug, is a large and

aggressive crayfish whose native range extends from northern Mexico to Florida and north to southern Illinois and Ohio. Often used in classrooms and as a popular food item, this highly adaptable crayfish has escaped to invade the Mid-Atlantic region and beyond, impacting aquatic ecosystems by chewing up vegetation, outcompeting native species, and altering water quality.



## Identification

Adult red swamp crayfish are a dark red color with raised bright red, white, or black spots (**tubercles**) covering the body and claws. Juveniles are a uniform gray sometimes overlain with dark wavy lines. Occasionally, a genetic mutation may turn the body and/or claws blue. A distinctive characteristic of this species is that the **areola** is linear to **obliterate**. The pincers are narrow and long and the **rostrum** has lateral spines or notches near its tip. Size is typically 5-13 cm (2-5 in).

## Similar Species

The red swamp crayfish most closely resembles the white river crayfish (*Procambarus acutus acutus*), and the southern white river crayfish (*Procambarus zonangulus*). White river crayfish have an **areola** that is narrow, but never **obliterated**, and the juveniles typically have spots on the **carapace** instead of wavy lines. White river crayfish can also be found in streams and ditches with a stronger flow than what's preferred by the red swamp crayfish.

## Habitat

The red swamp crayfish is tolerant of a wide range of habitats, including low oxygen levels, extreme temperatures, pollution, and areas with large water level fluctuations. It prefers marshes, swamps, ponds, and slow-moving rivers and streams where there is plenty of organic debris like logs, sticks, or water-soaked leaves. In times of drought or cold, the red swamp crayfish can burrow into the sediment until conditions are more favorable.

## Spread

Because this species is widely available through the seafood industry and aquarium trade, it is most likely spread when it is intentionally or unintentionally released. Aquarists who keep them as pets, teachers and students who use them as live study specimens, and consumers who purchased them from live food markets often release this species into the wild. The red swamp crayfish is also able to crawl out of water for long distances at night and during wet weather.

## Distribution

Native to the Gulf Coast and the Mississippi River drainage up to Illinois, the red swamp crayfish has spread widely throughout the United States, and is found in all Mid-Atlantic states.



## Impacts

The red swamp crayfish can quickly dominate lakes, ponds, rivers and wetlands. It feeds heavily on plants, snails, fish, and amphibians, competing with native crayfish and other species for food and habitat. It can also carry crayfish fungus plague which can lead to declines in native crayfish. In addition, its burrowing behavior can be problematic to levees, dams, and irrigation systems.



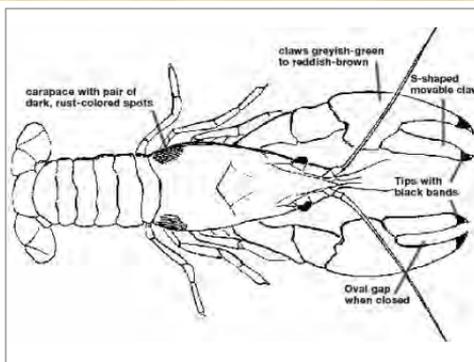
# Rusty Crayfish

*Orconectes rusticus*



## Species at a Glance

The rusty crayfish is a large, aggressive crustacean that can outcompete native crayfish for food and shelter, and devastate aquatic ecosystems with its huge appetite.



## Identification

The adult rusty crayfish is typically 8-13 cm (3-5 in) long, with large, black-tipped claws and smooth mouthparts. It is typically grayish-green to reddish-brown in color, with a set of dark rusty orange spots on each side of the **carapace**, which is its most distinguishing feature. Due to the **hybridization** of male rusty crayfish with female native crayfish, these spots may not always be present or well developed.

## Similar Species

May be confused with other native and invasive crayfish, including the calico crayfish (*Orconectes immunis*), virile crayfish (*O. virilis*), and northern clearwater crayfish (*O. propinquus*). However, these crayfish generally have smaller claws and lack the rusty orange spots present on the **carapace**.

## Habitat

The rusty crayfish is often found in silt, clay, or gravel substrates, and prefers areas with adequate rock, log, and debris cover; however, it can survive in a variety of habitats, including lakes, rivers, ponds, and streams. It is most active at temperatures above 8° C (46°F).

## Spread

Anglers using the rusty crayfish as bait is one of the most common ways it has spread to new regions. It is not necessary to have both males and females to establish a new invasion; a female carrying viable sperm could begin a new population if released into a suitable environment.

## Distribution

While its native range extends throughout the Ohio River basin in Ohio, Kentucky, Indiana, and parts of Tennessee and Indiana, the rusty crayfish has spread beyond this range to become invasive in other areas of the United States. In the Mid-Atlantic region, the rusty crayfish has established in all Mid-Atlantic states except for Delaware.



## Impacts

The rusty crayfish reduces native crayfish populations by competing for food and daytime hiding locations. It is a very aggressive and voracious eater, destroying aquatic plant beds and reducing food, shelter, and spawning sites for other organisms, including valued sport fish.



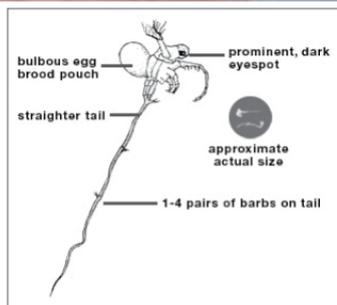
# Spiny Waterflea

*Bythotrephes longimanus*



## Species at a Glance

The spiny waterflea is a tiny freshwater crustacean that consumes native plankton and collects in cotton-like masses on fishing lines and cables. It has the potential to outcompete native fish and can threaten a lake's ecosystem.



## Identification

This species is not actually a flea, but rather a transparent crustacean or **cladoceran** that sticks on fishing lines and forms clumps that look and feel like gelatin with tiny black spots (eyes). Magnification is needed to see the transparent body, which ranges from 6-16 mm (0.2-0.6 in) long. The single, long, straight tail, which makes up to 70 percent of its length, has several spikes or barbs. The ball-shaped head with large eyes is clearly separated from the body.

## Similar Species

The fishhook waterflea (*Cercopagis pengoi*), which is smaller, also has a similar delicate spine; however, its tail has a distinctive looped hook at the end. It also has a more elongated and pointed brood pouch, in contrast with the spiny waterflea's bulbous, "balloon-shaped" brood pouch. The two may be difficult to identify without magnification.

## Habitat

Prefers large, deep, clear lakes with summer bottom temperatures of 10-24°C (50-75°F). It can also be found in wetlands, estuaries, rivers, and congregating in marinas. The spiny waterflea does not tolerate warm lake temperatures.

## Spread

Fishing, boating, and other recreational equipment can transport the spiny waterflea and its eggs to new waters. Enacting stricter ballast water regulations, avoiding the release of bait, rinsing boats and equipment with hot water sprayed at high pressure, and drying boats and equipment for five days before reentering the water could help prevent further invasion of this species.

## Distribution

While native to Europe and Asia, the spiny waterflea was most likely brought to the Great Lakes in the ballast water of ships traveling internationally. It was first found in 1984 in Lake Huron but is now found in all of the Great Lakes, including the Pennsylvania and New York portions of Lake Erie, and several inland lakes in New York.



## Impacts

The spiny waterflea decreases populations of native zooplankton and competes directly with juvenile and small fish for food, although it can be a food source for several freshwater fish.

Anglers consider it a nuisance because the tail spines hook onto and clog fishing lines and downrigger cables.



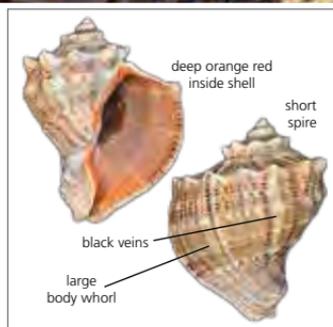
# Veined Rapa Whelk

*Rapana venosa*



## Species at a Glance

The veined rapa whelk is a large predatory snail found in the Chesapeake Bay. Its main diet consists of natural and cultivated populations of mollusks, such as oysters and mussels. Because of its predatory impact, it is considered one of the most unwelcome invaders worldwide.



## Identification

The heavy, rounded shell of this snail grows 15-18 cm (6-7 in) in length and is almost as wide as it is long, giving it a boxy appearance. It has a short **spire** and a large body **whorl**, and it varies in color from gray to reddish-brown with dark brown dashes on the spiral ribs. Most shells have distinctive black veins throughout. A diagnostic feature for this species is the deep orange color found on the inside of the shell.

## Similar Species

The large size, deep orange color inside the shell, and distinctive black veins distinguish the veined rapa whelk from any other type of snail in the United States.

## Habitat

This species is extremely versatile, tolerating low salinities, water pollution, and oxygen deficient waters. It favors compact sandy bottoms where it can burrow deep into the substrate.

## Spread

The veined rapa whelk lays clusters of eggs that form into free-floating larvae that eventually settle on the bottom to develop into a hard-shelled snail. This species may have been introduced as the larvae were transported in the ballast water of ships, or as egg masses were transported with products of marine farming.

## Distribution

Native to marine and estuarine waters of the western Pacific, from the Sea of Japan, Yellow Sea, East China Sea, and the Bohai Sea, the first veined rapa whelk specimen in the United States was collected in 1998 in Hampton Roads, Virginia. Adult specimens, as well as egg cases, continue to be reported from locations in the lower Chesapeake Bay along the western shore of Virginia.



## Impacts

The veined rapa whelk has caused significant changes in the ecology of bottom-dwelling organisms in its native range, and while scientists are still studying these impacts, there is great concern over its potential damage to native Chesapeake Bay species.

United States Distribution



# Virile Crayfish

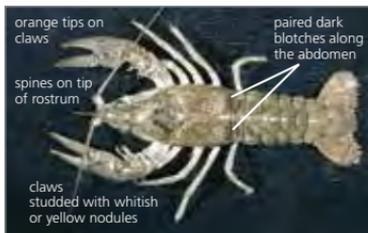
*Orconectes virilis*



## Species at a Glance

While native to the United States in the Missouri, Mississippi, Ohio, and Great Lakes drainages, the virile crayfish, also called the Northern crayfish, has become

introduced to new locations throughout the United States through the live pet and bait trades. In these areas it has competed with and displaced native fish and crayfish and reduced populations of snails, macroinvertebrates, and aquatic plants.



## Identification

Adult virile crayfish reach about 13 cm (5 in) long, with males typically growing larger than females. The body is reddish-brown, olive-brown, or green without any prominent markings. The pincers are green or blue-green with orange tips and are conspicuously studded with whitish or yellow nodules in adults. Paired dark blotches run lengthwise along the abdomen. The **rostrum** has conspicuous notches or spines near its tip.

## Similar Species

The virile crayfish is most often confused with the calico crayfish (*Orconectes immunis*) and spinycheek crayfish (*Orconectes limosus*). The calico crayfish differs in having pincers that are gray, purple, or pink, a pale lengthwise stripe along the middle of the abdomen, and a **rostrum** without lateral notches or spines. The spinycheek crayfish is smaller with distinctive spiny cheeks and legs with orange tips.

## Habitat

This species inhabits rivers, streams, lakes, marshes, and ponds that are permanent and well oxygenated. It prefers warm waters of moderate **turbidity** with cobble or rocky substrates and abundant logs, rocks, vegetation, and other debris to use as cover. It is also known to dig burrows in river banks and under rocks when water levels are low. It doesn't tolerate poor water quality or high salinity waters.

## Spread

Because it is commonly used as bait, and sold in bait shops and aquarium stores, many introductions of virile crayfish have probably occurred through intentional, or unintentional, release from these pathways.

## Distribution

Native to the Missouri, Mississippi, Ohio, and Great Lakes drainages of the United States, the virile crayfish has been introduced to several states outside of its native range, including Maryland, North Carolina, Pennsylvania, West Virginia, and Virginia in the Mid-Atlantic.



## Impacts

The virile crayfish can alter aquatic habitats by decreasing the abundance and diversity of aquatic plants and competing with native species for food and habitat. It has been known to negatively impact species of native crayfish, fish, frogs, snails, insects, and macroinvertebrates. Its burrowing behavior also impacts water quality and clarity by increasing **turbidity**, as well as impacting irrigation networks and levees.

United States Distribution



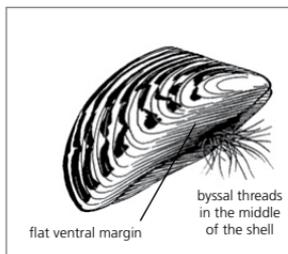
# Zebra Mussel

*Dreissena polymorpha*



## Species at a Glance

The zebra mussel is a small, fingernail-sized, freshwater mollusk that attaches to hard objects and costs billions of dollars to control and remove. Since its discovery in the Great Lakes, it has quickly spread to become one of the most intrusive, prolific, and costly aquatic invaders in North America. In many open-water environments, they can be virtually impossible to eradicate once established.



## Identification

Although the zebra mussel is named for the alternating light and dark bands present on the shell, color patterns can vary between black, brown, beige, and tan, with white to yellow stripes or zigzagged patterns. The shell is triangular or "D"-shaped, with a straight **midventral** line and a prominent ridge on each valve that allows the mussel to sit upright on its **ventral margin**. While size is typically 2-2.5 cm (0.8-1 in) in length, some mussels can reach up to 5 cm (2 in). The sticky, thread-like projections, called **byssal threads**, are located toward the middle of the shell and help it attach to hard substrates. Eggs develop into round, microscopic larvae called **veligers** that free-float in the water column for up to five weeks before settling. Under polarized light, **veligers** appear to be marked with a dark "X".

## Similar Species

A close relative, the quagga mussel (*Dreissena bugensis*) is also fingernail-sized but more rounded or fan-shaped, lacking the prominent ridges and flat **ventral margin** that allow the zebra mussel to sit upright. A quagga mussel would simply topple over if placed on its **ventral margin**. Also, the **midventral** line of the quagga mussel is curved, and the **byssal threads** are located toward the **anterior** end of the shell.

## Habitat

The zebra mussel can be found in lakes, rivers, reservoirs, ponds, and quarries. It requires enough calcium for shell production, and water temperatures over 10°C (50°F) for reproduction. It can be found attached to hard surfaces such as rocks, wood, concrete, steel, and even other organisms like native mussels and crayfish.

## Spread

One female zebra mussel can produce up to one million eggs in a breeding season. The free-floating **veligers** can be scooped up undetected and transferred in bait buckets, bilge water, and live wells. Because it can survive out of water for up to five days, this mussel is easily transported to other waterways on recreational boating, fishing, and diving gear.

## Distribution

While native to the Black, Azov, and Caspian sea drainages, the zebra mussel first appeared in the Great Lakes in Lake St. Clair in 1988, probably imported in contaminated ballast water. It has since spread throughout all of the Great Lakes, the Mississippi River drainage, and many inland lakes. In the Mid-Atlantic region, zebra mussels are established in Maryland, New York, Pennsylvania, and West Virginia.



## Impacts

The clustering behavior of the zebra mussel causes it to clog water intake pipes and damage equipment at power and water facilities, making it very expensive to remove and control. It also harms fisheries, alters water quality, and increases the growth of harmful algae. It decreases food sources for native species by filtering large amounts of microscopic plants and animals from the water, and it accumulates contaminants in its fatty tissues. The economic impact of zebra and quagga mussels in the U.S. is estimated in the billions of dollars.



# Invasive Mammals and Birds

---



While some of the species in this section are native to the region (i.e., migrant Canada goose), or may be considered terrestrial or semi-aquatic, they are considered important species in aquatic invasive species management because they have the potential to severely impact and alter aquatic ecosystems. Species such as feral swine and nutria threaten the diversity and abundance of native aquatic species by degrading habitat, reducing water equality, depleting valuable wetland vegetation, and causing stream bank erosion and degradation. Birds like mute swans and resident Canada geese can decrease biodiversity of native aquatic birds and wildlife and create health threats as their droppings enter water systems and residential areas. Early detection and identification of these species is a first line of defense against possible damage to aquatic ecosystems and species and should be reported immediately if found in new locations.



# Feral Hog

*Sus scrofa*



## Species at a Glance

The feral hog, also known as the feral pig, feral swine, or wild boar, is a feral representative of the same species including all domestic pigs. Brought to North America from Europe and Asia as a domestic livestock, or through introductions of wild boar, the feral hog has since established wild populations that pose serious ecological, economic, and public health threats.



## Identification

The feral hog exhibits a wide range of colors and sizes. The average sow weighs 35-150 kg (77-330 lbs) and the average boar weighs from 59-200 kg (130-440 lbs). The hair is coarse, with long bristles. Color ranges from solid black, gray, brown, blonde, or red to striped, spotted, or grizzled color combinations. The elongated snout is flattened at the end and is tough and flexible. Males have four tusks that grow continually and can be extremely sharp. Upper tusks can be as long as 8-13 cm (3-5 in) and are usually worn or broken from use. The feet are cloven and the tail is often straight and moderately long, with sparse hair. Signs of the feral hog can include tracks, rubbings on nearby trees, rootings, and muddy wallows. In some areas, escaped or free-ranging pigs may be legally considered feral based on their location and lack of documented ownership, rather than on physical appearance.

## Similar Species

Not to be confused with recently escaped domestic pigs, the feral hog roams free and is not tame. Escaped, or free-ranging “domestic pigs” left unattended or abandoned to roam free may quickly convert to feral condition.

## Habitat

The feral hog can adapt to almost any kind of habitat, from tropical coastal marshes to sub-arctic latitudes. In the Mid-Atlantic region, it prefers habitats with an abundant supply of food, water, and dense cover such as swamps, shrubby communities, riparian zones, forests, agricultural fields, and urban or suburban greenways.

## Spread

Through natural population growth, illegal movement by sport hunters, and escape from domestic swine operations, the feral hog has quickly spread and established wild breeding populations. It is a prolific breeder, capable of tripling its population in 14-16 months. Females reach sexual maturity at 5-6 months of age, producing 2-3 litters per year of 4-8 piglets.

## Distribution

Pigs were first introduced to North America from Europe around 1539, likely as semi-domestic livestock descended from Eurasian swine. Additional introductions of wild Eurasian boars from Europe and Asia for sport hunting occurred throughout the 1800s and 1900s. Over many decades, these diverse stocks have converged to form free-ranging feral hog populations which have quickly spread across the United States. Experts estimate current numbers at over 5 million animals nationwide. As of 2016, the feral hog has been reported from every Mid-Atlantic state, though no established populations occur in Maryland.



## Impacts

The feral hog can be destructive to fields, fences, and other infrastructure, wetlands, and many wildlife species. Its wallows can affect ponds and wetlands, muddying the water and destroying aquatic vegetation.

Its rooting behavior facilitates the invasion of noxious weeds and reduces diversity and distribution of native species.

The feral hog can span a field of crops in one night, and pose a predatory threat to ground nesting birds and other wildlife. It can also transmit diseases and parasites to wildlife, livestock, pets and humans.



# Mute Swan

*Cygnus olor*



## Species at a Glance

Although many people enjoy its beauty, the mute swan is a large and aggressive bird that originated in Europe and Asia. It adversely impacts ecosystems by uprooting valuable aquatic plants, outcompeting native birds, attacking native wildlife and humans, and carrying disease agents like *E. coli*.



## Identification

The mute swan is a very large bird, measuring 142-157 cm (56-62 in) in length and weighing 11-14 kg (25-30 lbs). Adults have all white **plumage**, vibrant orange bills, and a black knob present above the bill. Young birds have grayish bills. When swimming, the mute swan often holds its wings slightly upraised over its back, forming a hump. The conspicuous curved neck is held in an "S"-shape, with the bill held downward while swimming.

## Similar Species

The most notable difference between the mute swan and native swans, like the trumpeter swan (*Cygnus buccinator*) and the tundra swan (*C. columbianus*), is that adult mute swans have an orange bill, while the native swans have black bills. The mute swan also has a black knob on top of the bill that is absent in the native swans. The “S”-shaped curve in the mute swan also distinguishes it from the trumpeter swan, which has a “C”-shaped neck.

## Habitat

This species can be found in both marine and freshwater environments, including ponds, slow rivers, coastal bays, and inland lakes. It prefers habitats infested with phragmites and cattail that it can use for nesting material and that provide protection from potential predators.

## Spread

It is widely thought that all North American mute swan populations originated from the release or escape of individuals from early captive flocks that were brought to the United States for ornamental purposes. Because it is relatively long-lived, reaching over 25 years in some wild populations, the mute swan has the potential to increase its population size rapidly if left unchecked.

## Distribution

Native to Europe and parts of Asia, the mute swan was intentionally brought to the United States in the mid-1800s to the early 1900s to beautify city parks, zoos, and private estates. However, a small number of birds escaped into the wild in New Jersey and New York, allowing Atlantic Flyway populations to form. This species can now be found from southern Ontario to North Carolina, with “semi-domestic” flocks ranging south to Florida.



## Impacts

The mute swan is capable of uprooting about 20 pounds of submerged aquatic vegetation per day that would otherwise provide important food and shelter for native fish and wildlife. The mute swan also behaves aggressively toward other birds and even humans. It chases native water birds to keep them from nesting, and in extreme cases, can attack and kill ducklings, goslings, or other small water birds.

United States Distribution



# Nutria

*Myocastor coypus*



## Species at a Glance

The nutria, also called the coypu, is a large, semi-aquatic rodent that was brought to the United States as an important resource for the fur farming industry. When the fur market collapsed in the 1940s, nutria were released into the environment, impacting thousands of acres of coastal wetlands

as they grazed on native marsh vegetation and burrowed into dikes, levees, and littoral banks.



## Identification

The nutria is a furry, swimming rodent that can weigh 7-9 kg (15-20 lbs) and reach 0.6 m (2 ft) long. It is light to dark brown with a large head, short legs, and a stout body that appears hump-backed on land. Its large front teeth can range in color from yellow to orange-red. It is highly adapted for aquatic ecosystems with partially-webbed hind feet; a long round tail; and eyes, ears, and nostrils that are set high on the head, allowing them to stay above the waterline while swimming.

## Similar Species

Often mistaken for beavers and muskrats, the best way to distinguish the nutria is to look at the size, tail, and head. An adult nutria is about one-third the size of an adult beaver and five to eight times larger than an adult muskrat. A beaver has a large, broad, flat tail, and a muskrat has a long narrow tail that whips back and forth when swimming. The nutria has a heavy rat-like tail thinly covered in bristly hairs that trails smoothly behind it when swimming.

## Habitat

This species has adapted to a wide range of freshwater, estuarine, and saltwater habitats, but is usually found in and along lakes, marshes, and slow-moving streams. It prefers habitats with an abundance of **emergent** vegetation, small trees, shrubs, and other succulent vegetation along the banks. It can also be found under buildings, in overgrown lots, on golf courses, and in storm drains.

## Spread

The nutria was first imported into the United States for nutria "ranching", which became very popular in the 1930s. After the collapse of the fur market, thousands of nutria were released by ranchers who could no longer afford to keep them, or they escaped into the wild. Other than fur harvesters, alligators are the only significant predator of the nutria; however, even in areas with an abundance of alligators, this species can thrive if habitat conditions are suitable.

## Distribution

Native to South America, the nutria was introduced into the United States in 1899. Accidental and intentional release of this species allowed it to become established in at least 16 states, including Delaware, Maryland, North Carolina, and Virginia in the Mid-Atlantic Region.



## Impacts

The nutria feeds heavily on marsh grasses and aquatic vegetation, reducing diversity and abundance of native plants and impacting valuable fish and wildlife habitats. Intense grazing can destroy roots and mats, increasing erosion and resulting in barren mudflats and open water. The nutria can also impact important crops like sugarcane, rice, corn, and various fruits and vegetables, resulting in substantial financial losses for farmers. Its burrowing behavior can weaken the foundations of reservoirs, dams, buildings, road beds, and flood control levees. It can also serve as hosts for several pathogens and parasites which can contaminate drinking water supplies and swimming areas.



# Resident Canada Goose

*Branta canadensis*



## Species at a Glance

The Canada goose in the Atlantic flyway population is comprised of two large subpopulations; a native population of migrant geese that overwinters in the Mid-Atlantic region, and an introduced population of non-migratory resident geese.

The resident Canada goose is a product of intentional stocking and is now established throughout the Atlantic flyway states and southern Canada. Since its introduction, populations of the resident goose have increased dramatically, with numerous ecological, agricultural, and aesthetic impacts.



## Identification

The Canada goose is a large waterfowl weighing up to 8 kg (18 lbs). It has a long neck, large body, large webbed feet, and a wide flat bill. Both sexes have a black head and neck with broad white cheek patches that extend from the throat to the rear of the eye. The breast, abdomen, and **flanks** are light gray to dark chocolate brown. The back and tail are usually dark brown to black with a white U-shaped band on the rump. It is often seen in flight moving in V-shaped flocks.

## Similar Species

The cackling goose (*Branta hutchinsii*) was once considered the same species as the Canada goose; however, the cackling goose is much smaller and has a tiny, stubby, triangular bill. In addition, the greater white-fronted goose (*Anser albifrons*) has a brown, not black, neck and lacks the white cheeks and throat. The snow goose (*Chen caerulescens*) has an all-white head and body with black wing tips. The Atlantic brant (*Branta bernicla*) has a dark chest and the white is limited to the neck.

## Habitat

A highly adaptable species, the resident Canada goose uses a variety of habitats including islands in rivers and lakes, marshes, reservoirs, golf courses, agricultural fields, and grassy fields near water. It thrives in typical suburban landscapes that provide food in the form of grassy open areas and ponds for water and roosting.

## Spread

The resident Canada goose is highly mobile and able to fly long distances to find food and nesting areas. It is also very prolific. In contrast to the migrant Canada goose, the resident Canada goose has few natural predators and gosling production is not as impacted by spring weather conditions.

## Distribution

Stocking and releases of the resident Canada goose began in the early 1900s. It now nests throughout the Atlantic flyway states and southern Canada. It typically moves south only when forced by snow and ice. The population of the resident Canada goose in the Atlantic flyway has increased dramatically in the last 40 years and now totals over 1 million.



## Impacts

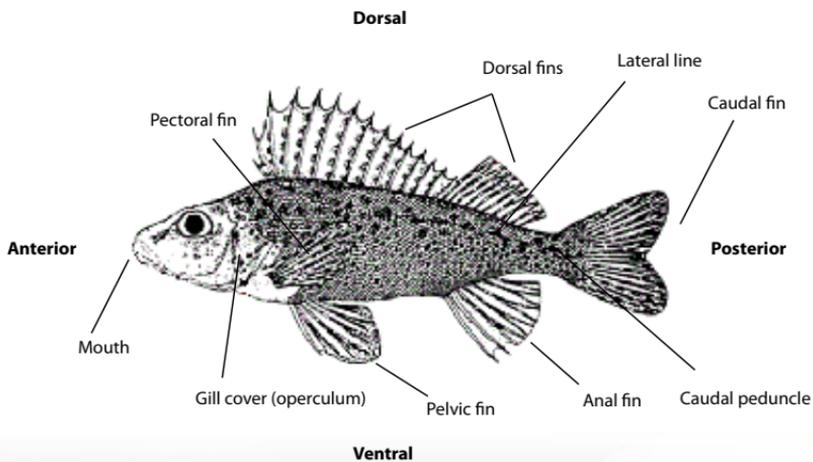
Grazing by the resident Canada goose, particularly during the growing season, can damage native vegetation and agricultural crops. In addition, goose droppings can impact water quality by adding excessive nutrients. The presence of goose feces in residential areas is not only a nuisance, but can damage property and pose a potential human health threat.

United States Distribution

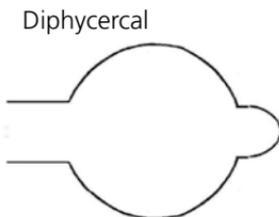
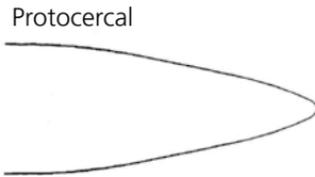
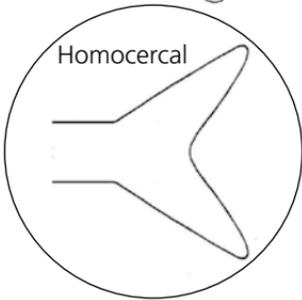
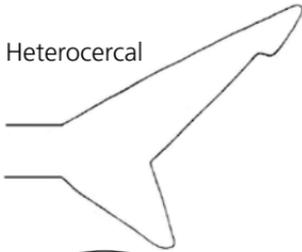


# Fish Anatomy

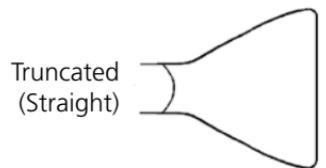
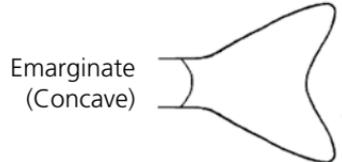
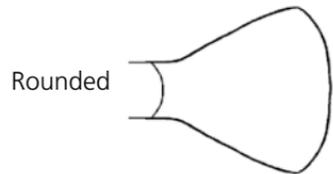
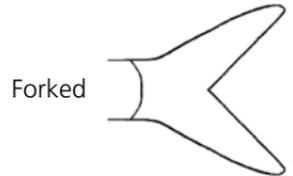
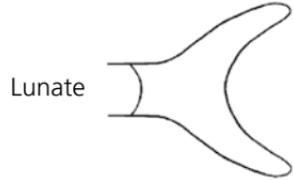
---



**Types of Caudal Fin**



**Shapes of Homocercal Caudal Fins**



# Asian Swamp Eel

*Monopterus albus*



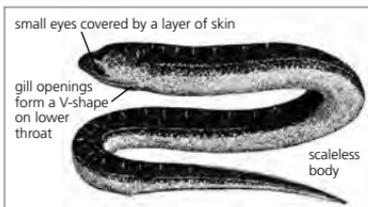
## Species at a Glance

The Asian swamp eel, also called the rice eel, is a member of the swamp-eel family, *Synbranchidae*.

With the help of specialized gills, it has the ability to breathe atmo-

spheric oxygen, allowing it to live in shallow, deoxygenated waters.

In addition, the Asian swamp eel can reverse its sex, with most maturing as females and some changing to males over time.



## Identification

This elongate, snake-like, and cylindrical fish typically has no scales, and no **pectoral** or **pelvic fins**. **Dorsal**, **caudal**, and **anal fins** are reduced to folds of skin without fin rays. The head is relatively short and the teeth are small and not easily seen. Eyes are small and covered by a layer of skin. The gill openings form a “V”-shape on the lower throat area. The body and head are dark olive or brown in color above, becoming lighter (often a light orange) below. Some individuals are brightly colored with yellow, black, and gold spots over a light tan, or almost white background. The skin produces a thick mucus layer making the eel difficult to hold. It may grow as long as 0.9-1 m (3-4 ft) and weigh as much as 1 lb.

## Similar Species

The Asian swamp eel is most often confused with the American eel (*Anguilla rostrata*), as well as some species of lamprey. The American eel can be distinguished by the presence of pectoral fins, which are absent in the Asian swamp eel. Lampreys are best identified by seven small pore-like gill openings. This species may also be confused with other invasive swamp-eels such as *M. cuchia* which is similar to *M. albus* in appearance, habitat, and behavior; however, *M. cuchia* has small scales that are absent in *M. albus*.

## Habitat

Ideal habitat for the Asian swamp eel is tropical and temperate climates with slowly moving freshwater systems such as agricultural areas, wetlands, muddy ponds, canals, swamps, and rice fields. It is nocturnal and will often burrow into soft, moist sediments where it can survive in low oxygen waters and can even gulp air to survive without water for an extended period.

## Spread

While it's unclear exactly how the Asian swamp eel was introduced, it was most likely released or escaped from aquariums, fish farms, or through the live fish food market. Because it can breathe air, it may have the ability to move across land, although no occurrences of overland travel have been documented.

## Distribution

Native to tropical and temperate parts of Southeast Asia, the Asian swamp eel was first brought to Hawaii around 1900. Current populations are established in Hawaii, Georgia, Florida, and New Jersey. In 2014, Asian swamp eels were found in Maryland; however, they are not currently established.



## Impacts

This species has characteristics that make it very adaptable to new environments. It currently has no known predators in North America; therefore, it has the potential to grow and spread quickly and become widespread in the United States. Because they are a generalized predator, the Asian swamp eel is a potential threat to native fishes, frogs, and aquatic invertebrates.



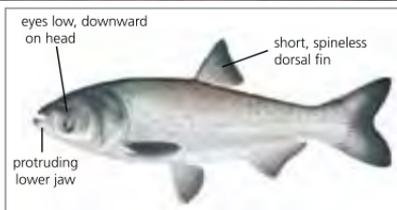
# Bighead Carp

*Hypophthalmichthys nobilis*



## Species at a Glance

The bighead carp is a member of the Asian carp complex, which includes silver, black, and grass carp. As of 2016, there are no established populations in the Mid-Atlantic Region; however, its large size and voracious appetite make it an enormous threat to the area. Any potential sightings should be reported immediately.



## Identification

The body of the bighead carp is large, reaching 1-1.5 m (3.3-4.9 ft) in length and weighing over 100 pounds. It is broad, **fusiform**, and **laterally compressed** with a solid dark gray top blending to white underneath. It has many irregular gray-black blotches on its sides. Its large head lacks scales and its big **terminal** mouth lacks barbels and teeth. The lower jaw also protrudes out farther than the upper jaw. The eyes are situated low on the head and are positioned downward. The short **dorsal fin** lacks spines, and contains 7-10 rays. Scales are very small and resemble those of a trout.

## Similar Species

The bighead carp most closely resembles the invasive silver carp (*Hypophthalmichthys molitrix*). The **keel** of the bighead carp runs from the **pelvic fins** to the **anal fins**, while the silver carp has a **mid-ventral keel** that is more extensive and runs from the **anal fins** up to the base of the gills. Silver carp also lack the dark blotches characteristic of the bighead carp. The bighead carp may also resemble the common carp (*Cyprinus carpio*), which has **barbels** on either side of the mouth, or species of suckers (*Catostomidae*), which have thick lips containing small nipple-like bumps.

## Habitat

The bighead carp lives exclusively in freshwater and prefers large river systems with flowing water that is needed for spawning. It will also inhabit lakes and ponds.

## Spread

Once introduced to open waters, the bighead carp can readily spawn and disperse itself. Because juveniles of this species can resemble common baitfish species, it may be unintentionally spread through the use of live bait. Spread can also occur as it is sold through the live Asian food market.

## Distribution

Native to eastern Asia, the bighead carp was intentionally introduced into the United States to control algae in aquaculture ponds. During flooding in the early 1980s, it escaped into the Mississippi River and has since moved upstream towards the Great Lakes. There is evidence of reproducing populations in the middle and lower Mississippi and Missouri Rivers and in the Ohio River. The bighead carp is also in the Illinois River, which is connected to the Great Lakes via the Chicago Sanitary and Ship Canal. In the Mid-Atlantic region, bighead carp were successfully eradicated from a private fish culture facility in Hunterdon County, New Jersey, and an isolated bighead carp individual was caught by an angler in the Raritan River in New Jersey in the late 1990s. However, there are currently no established populations in the Mid-Atlantic region.



## Impacts

The bighead carp can consume up to 40 percent of its body weight in plankton and detritus per day, competing with native filter feeders and juvenile fish for food. This impact on the food web and trophic structure of an ecosystem could result in large population declines, impacting biodiversity as well as commercial and recreational fishing.



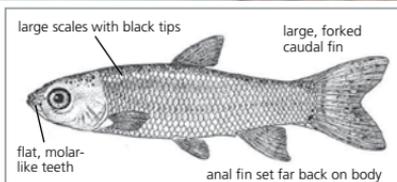
# Black Carp

*Mylopharyngodon piceus*



## Species at a Glance

The black carp is a member of the Asian carp complex, which includes silver, bighead, and grass carp. This species is a molluscivore and has powerful teeth that allow it to crack open mussels, snails, and other hard-shelled organisms.



## Identification

The elongate, **fusiform**, slightly compressed body of the black carp averages 1-1.5 m (3.3-4.9 ft) in length. Color can vary, but is usually dark brown to black on the back and sides with some white on the underside, with dark fins. The mouth is small, **terminal**, and lacks barbels. Teeth are strong, flat and molar-like, and are arranged in rows of 4-5 on each side. The scales are very large and have black tips, giving its body the appearance of cross-hatching. Fins lack spines. The **anal fin** is set far back on the body, and the **caudal fin** is large and forked. Average weight is about 15 kg (33 lbs), but some black carp can reach up to 68 kg (150 lbs).

## Similar Species

The best way to distinguish the black carp from the grass carp (*Ctenopharyngodon idella*) is by looking at the **pharyngeal** teeth. Black carp teeth appear molar-like, whereas the grass carp's teeth have deep parallel grooves. The black carp may also resemble the common carp (*Cyprinus carpio*), which has **barbels** on either side of the mouth, and species of suckers (*Catostomidae*), which have thick lips containing small nipple-like bumps.

## Habitat

The black carp is exclusively freshwater and prefers large river systems and embayments in temperate to subtropical climates.

## Spread

The availability of the black carp in the live fish market may have created a risk for accidental or unlawful release. Additional introduction and spread occurs as fish escape from holding facilities and naturally disperse to new areas.

## Distribution

The black carp is native to eastern Asia from southern Russia to northern China. It was brought to the United States to control snail populations in aquaculture facilities and escaped from holding ponds during flooding in 1994. Individuals have since been found in the lower part of the Mississippi River basin. There are no reports of black carp in the Mid-Atlantic.



## Impacts

The black carp poses a considerable threat to native mussel and snail populations. It can live up to 15 years, consuming several pounds of mollusks each day and competing with native fish, turtles, birds, and some mammals for food. The black carp may also be a vector for parasites and diseases affecting native species.

United States Distribution



# Blue Catfish

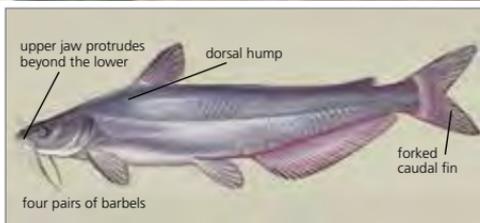
*Ictalurus furcatus*



## Species at a Glance

Often confused with the channel catfish (*Ictalurus punctatus*), the blue catfish is the

largest species of North American catfish, reaching up to 150 pounds and living up to 20 years. Populations of non-native catfish such as the blue and channel catfish have increased dramatically since their introduction, and are now present in every major Chesapeake Bay tributary.



## Identification

The long, heavy body of the blue catfish is smooth and scaleless with a wide head and a high spot near the center of the head called the **dorsal hump**. The upper jaw protrudes well beyond the lower. It has a slate blue body above, fading to silver-white on the sides and belly. The outer **margin** of the **anal fin** is straight, and the **caudal fin** is deeply forked. Four pairs of black, whisker-like barbels appear around the mouth. Adults usually grow to be less than 0.6 m (2 ft) long, but can be as long as 1.5 m (5 ft) and weigh more than 45 kg (100 lbs).

## Similar Species

Small blue catfish are often confused with channel catfish. The channel catfish rarely exceeds 14 kg (30 lbs) and smaller individuals often have dark spots that are not found on the blue catfish. Large channel catfish and medium-sized blue catfish can be more difficult to tell apart, often having similar coloration and general body shape. The **margin** of the **anal fin** can be used to differentiate these fish. The blue catfish has an **anal fin** with a very straight **margin** and the channel catfish has a rounded **margin**. They can also be distinguished by counting fin rays in the **anal fin**; 30-35 rays in the blue catfish and 25-29 rays in the channel catfish.

## Habitat

While the blue catfish lives primarily in freshwater, it can thrive in brackish waters and has a high tolerance for different habitats and water conditions. It is a bottom dweller, preferring large rivers with deep channels, swift currents, and sandy bottoms.

## Spread

Intentionally stocked as a food fish, sport fish, and to feed on populations of the invasive Asian clam, the blue catfish has established and spread to new locations through connected waterways, and by escaping catfish farms during floods. With a long lifespan and females producing 4,000 to 8,000 eggs per kilogram of body weight, it has continued to expand its range and population.

## Distribution

Native to the Mississippi, Missouri, and Ohio River basins, the blue catfish has been stocked in at least 20 states. During the 1970s and 1980s, they were introduced into the James, Rappahannock, and York rivers in Virginia and populations have expanded into nearly every major tributary in the Chesapeake Bay watershed.



## Impacts

Because of its adaptability, diverse diet, large size, and growing numbers, there is concern about the potential impacts blue catfish may have on native species of fish and shellfish in the Chesapeake Bay. In some studies on the James and Rappahannock rivers, invasive catfish such as the blue and flathead catfish have been estimated to compose up to 75 percent of the total weight of all fish inhabiting certain stream reaches.

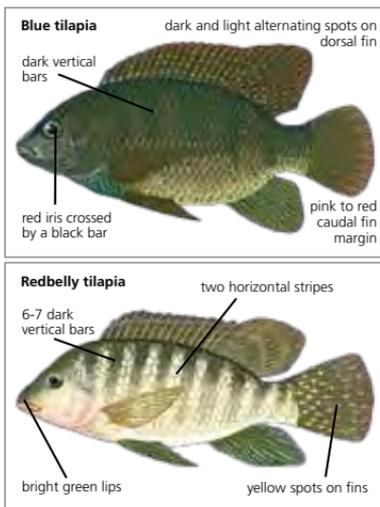


# Blue Tilapia and Redbelly Tilapia

*Oreochromis aureus* and *Tilapia zillii*

## Species at a Glance

Tilapias are resilient, prolific, easy to grow, and appeal to many consumers with their mild flavor and white flesh. Therefore, species like the blue and redbelly tilapia have become economically important food fish throughout the world. Unfortunately, escape into the natural environment has given them the potential to outcompete native species and negatively impact aquatic communities.



## Identification

The body of the blue tilapia is blue and silver with dark vertical bars that may not always be apparent. Dark and light spots alternate on the posterior half of the **dorsal fin** and the upper **margin** is red or orange in color. The **caudal fin** also has a broad pink to red **margin**. The eye has a red iris that is crossed by a black bar. Males are significantly larger than females, reaching a maximum length of 50 cm (20 in). Breeding males exhibit a bright metallic blue on the head and a more intense pink on the fins, as well as a blue-black chin and chest.

The redbelly tilapia is olive-colored on top and light olive to yellow-brown on the sides, often with an iridescent blue sheen. Lips are bright green and the chest is pinkish. Six to seven dark vertical bars cross two horizontal stripes on the body and **caudal peduncle**. Fins are covered in yellow spots, with the **dorsal** and **anal fins** displaying the outline of a thin orange band. Spawning coloration is a shiny dark green on the top and sides, red and black on the throat and belly, and obvious vertical bars on the sides. The heads turn dark blue to black with blue-green spots. It reaches a maximum length of 40 cm (15.7 in).

## Similar Species

The blue tilapia has little or no breeding coloration in males in contrast with the redbelly tilapia. The redbelly tilapia is also similar to the spotted tilapia (*Tilapia mariae*), but differs in that the spotted tilapia lacks the blood red coloration, it has 5-6 black square blotches on its side, and the stripes on its side extend onto the **dorsal fin**.

## Habitat

Both tilapia species can be found in lakes, wetlands, marine habitats, watercourses, and estuaries. They prefer tropical habitats, but the blue tilapia can tolerate cold temperatures as low as 8°C (46°F). The redbelly tilapia has the ability to establish in highly salinated waters. Both species are considered hardy and tolerant of a wide range of water quality and habitat conditions.

## Spread

Tilapias introductions have occurred through many vectors, including intentional stocking for experimental work by states and private companies, as forage for warm water predatory fish, as a food source, as a control for aquatic plants, and through unintentional escapes.

## Distribution

Native to parts of Africa and the Middle East, blue and redbelly tilapia were annually stocked in states like Alabama and Arizona from the late 1950s to the 1970s. They can now be found established in several states throughout the U.S. and in the Mid-Atlantic region in North Carolina and South Carolina.



## Impacts

These tilapias have the ability to spread rapidly and in large numbers, allowing them to effectively compete with native species for food and nesting space. The redbelly tilapia can also alter native benthic communities through the elimination of plants, and will often exhibit aggressive behavior towards other fish.

United States Distribution - Blue



United States Distribution - Redbelly



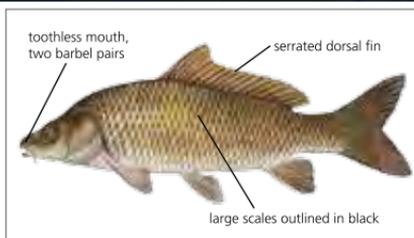
# Common Carp

*Cyprinus carpio*



## Species at a Glance

The common carp is a voracious, omnivorous fish and one of the largest members of the minnow family *Cyprinidae*. It is long-lived with a lifespan of up to 50 years. Varieties of common carp include mirror carp, leather carp, and koi, which is popular in small ponds and water gardens.



## Identification

The body is heavy and stout, bronze, brassy, or yellow in color, and has large scales usually outlined in black. Spine-like rays are present at the front of the **dorsal** and **anal fins**. The head is short with a rounded snout, a toothless sucker-like mouth, and two pairs of barbels on each side of the upper jaw. Its average length is 25-55 cm (10-22 in) and it typically weighs 0.5-4.5 kg (1-10 lbs), although some can reach up to 122 cm (48 in) long and weigh up to 36 kg (80 lbs).

## Similar Species

The common carp resemble the smallmouth buffalo (*Ictiobus bubalus*), bigmouth buffalo (*I. cyprinellus*), grass carp (*Ctenopharyngodon idella*), and other species of carp. The best way to identify the common carp is by the two barbels on each side of the mouth and the long dorsal fin.

## Habitat

This species generally inhabits lakes, ponds, and the lower sections of rivers, usually with moderately flowing or standing water. It is also found in brackish-water estuaries, backwaters, bays, and in shallow water during spring spawning.

## Spread

Once introduced, the common carp can migrate through natural waterway connections to other bodies of water. It can also be spread by anglers using juvenile carp as bait.

## Distribution

Native to Europe and Asia, the common carp was intentionally introduced into the United States in the 1880s as a food and game fish. It is now prevalent throughout the entire United States and is found in every state in the Mid-Atlantic.



## Impacts

The common carp's foraging behavior causes it to dislodge and destroy vegetation, increase water **turbidity**, impact native species' spawning sites, and decrease water quality. It also releases phosphorus that increases algae abundance and production.

United States Distribution



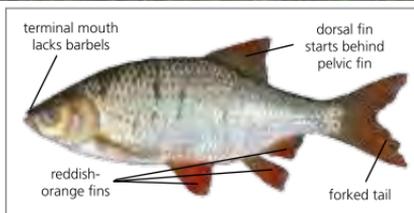
# European Rudd

*Scardinius erythrophthalmus*



## Species at a Glance

The European rudd is a medium-sized fish belonging to the minnow family. It is carnivorous when young, feeding on snails, insects, and small crustaceans, but prefers aquatic vegetation as it gets older.



## Identification

The body of the rudd is somewhat stocky, robust, and elliptical in shape, with large scales and a forked tail. It has a scaled, **keel**-like belly that runs from the **pelvic** to the **anal fins**. Coloration is brownish-green above and brassy yellow to rosy on the sides, fading to silvery underneath. The **pectoral**, **pelvic**, and **anal fins** are a distinctive bright reddish-orange color. The mouth is **terminal** and lacks barbels, and the lower lip is sharply angled with a protruding lower jaw. The iris of the eye is yellow to orange, often with a red spot that can cover the pupil. Another identifying feature of the rudd is that the beginning of its **dorsal fin** is set well behind the front of the **pelvic fin**. Maximum size is up to 48 cm (19 in) in length.

## Similar Species

Young rudd can be confused with golden shiners (*Notemigonus crysoleucas*); however, adult rudd reach much larger sizes. The rudd has 6-9 scales on the belly, whereas the golden shiner has a naked, scale-less belly. In addition, the fins of the golden shiner are clear to pale orange, not bright orange or red, and it lacks the red spot on the iris above the pupil.

## Habitat

The European rudd prefers still and sluggish waters in the weedy shoreline areas of lakes and rivers, but it can adapt to a wide range of environmental conditions, including poor water quality.

## Spread

Bait bucket release is the primary mechanism by which the rudd has gained access to open waters. Because it is similar to the golden shiner, it can become mixed in with shiner shipments to bait dealers and become introduced into new environments by anglers.

## Distribution

Native to Europe and western Asia, the European rudd was most likely introduced to the United States as a game and food fish. Since its introduction, it has spread throughout much of the country and has been collected in 21 states. In the Mid-Atlantic region, the rudd can be found in New York, Pennsylvania, Virginia, and failed populations have occurred in New Jersey and West Virginia.



### Impacts

Although the rudd's impacts are mostly unknown, it may compete with native fish for invertebrate food sources and influence the population dynamics of ecosystems.



# Flathead Catfish

*Pylodictis olivaris*



## Species at a Glance

The flathead catfish is one of the largest species in the catfish family and it can live for up to 20 years. It feeds voraciously on other fish, making it a possible threat to native ecosystems. It has many nick-names, including pied cat, mud cat, Mississippi cat, shovelhead cat, yellow cat, and Opelousa cat.

## Identification

Key characteristics of the flathead catfish are its flattened head, tiny eyes, squared tail, and protruding lower jaw. It can grow up to 152 cm (60 in) long and weigh on average 14 kg (30 lbs), although some have been known to reach over 45 kg (100 lbs). Coloration is usually brownish-yellow with mottled speckles on the back and a cream-colored white to yellow belly.

## Similar Species

Most often confused with the channel catfish (*Ictalurus punctatus*), the flathead catfish is nearly double its weight. The lower jawbone of the flathead extends outward from the rest of the face, like an under-bite, whereas the channel catfish's upper jaw extends over the lower. The channel catfish also has a forked tail instead of a squared tail.

## Habitat

Thriving in reservoirs, lakes, rivers, and large streams, the flathead catfish prefers deep, still, muddy waters with logs and other debris to use as shelters.

## Spread

The most likely vector of spread is intentional stocking and release by anglers for game and food fishing.

## Distribution

Native to North America, including areas of the Mississippi River Basin, the Great Lakes, and the Ohio River drainage, flathead catfish are invasive in western states and throughout the entire Mid-Atlantic region, extending down to Florida.



## Impacts

Because it is fast-growing, long-lived, and feeds voraciously on other fish, the flathead catfish poses a threat to the region's ecologic and economic resources, such as native fish populations. Species such as sunfish and native catfishes have declined heavily in some areas where flathead catfish are present.



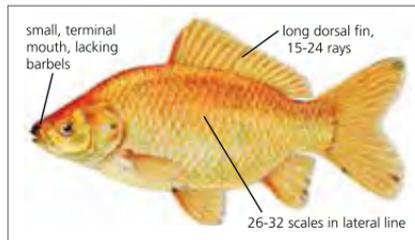
# Goldfish

*Carassius auratus*



## Species at a Glance

The goldfish, which is a member of the minnow family, was one of the first aquatic invasive species to reach North America, arriving in the 1600s as ornamental fish for aquariums and water gardens. It is now one of the world's most widespread invasive species.



## Identification

The elongated, stout body is typically 10-20 cm (4-8 in) in length and weighs 0.03 kg (0.06 lbs), although it can reach a maximum length of 59 cm (23 in) and maximum weight of 3 kg (7 lbs). It has a long **dorsal fin** with 15-24 rays and a hard **serrate** spine at the origin of both the **dorsal** and **anal fins**. There are normally 26-32 scales in the **lateral line**. The mouth is small, **terminal**, and lacks barbels. While the goldfish was mostly golden in color one thousand years ago, it now comes in a variety of colors, including orange, yellow, white, black, silver, olive-green or greenish-brown and combinations of these colors. When found in nature, the goldfish is most often a shade of green, brown, or gray.

## Similar Species

The goldfish may be confused with the common carp (*Cyprinus carpio*), which has two pairs of barbels on the upper jaw, a non-**serrate** spine, and typically more than 32 scales in the **lateral line**. However, goldfish can **hybridize** with the common carp, producing individuals with both characteristics.

## Habitat

While preferring a habitat with a muddy bottom and thick vegetation, the goldfish can tolerate pollution, temperature fluctuations, and high levels of **turbidity**. It lives in freshwater ponds and slow-moving or still waters in depths of up to 19.8 m (65 ft) and prefers temperatures of 4-41°C (40-106°F); although it cannot live for long at high temperatures.

## Spread

Intentionally introduced to ponds, fountains, and small lakes for ornamental purposes, the goldfish was able to escape and disperse through connecting waters. Many introductions of goldfish were also due to its use as live bait. In addition, the goldfish is often released into the wild by pet owners not realizing the environmental repercussions of setting the fish free.

## Distribution

Native to eastern Asia, the goldfish has been reported invasive in the United States by every state except for Alaska, and is established in all of the Mid-Atlantic states.



## Impacts

The goldfish is believed to be responsible for population declines in many native fish, invertebrate, and plant species. It also uproots plants and creates enormous **turbidity** due to its aggressive bottom feeding behavior.

United States Distribution



# Grass Carp

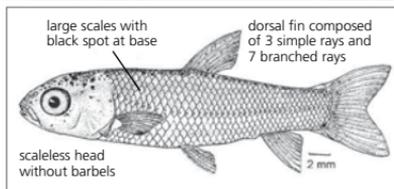
*Ctenopharyngodon idella*



## Species at a Glance

The grass carp, also known as the white amur or the waan ue, is one of the largest minnows in the family *Cyprinidae*.

It is also a member of the Asian carp complex, which includes the black, bighead, and silver carp. It was introduced into the United States to help control the growth of aquatic weeds in aquaculture facilities, but escaped into natural systems and is now widespread throughout the U.S.



## Identification

The body of the grass carp is oblong in shape but considered slender for most carp. It typically reaches 29-36 kg (65-80 lbs), although individuals as large as 45 kg (100 lbs) have been reported. Scales are large, with dark edges and a black spot at the base. The scaleless head lacks **barbels**. Overall color is olive to silvery-white, while the fins are a clear to gray-brown. The **dorsal fin** is composed of three simple rays and seven branched rays.

## Similar Species

The grass carp may be confused with the common carp (*Cyprinus carpio*), which can be distinguished by the presence of barbels around the mouth. The common carp is also more golden in color and has spiny modified rays on the **dorsal** and **anal fins**.

## Habitat

The grass carp prefers shallow and quiet waters, typically 0.9-3 m (3-10 ft) deep, such as ponds, lakes, pools and backwaters of large rivers.

## Spread

Once introduced, the grass carp can spread to distant water bodies by tributaries, waterways, river systems, canals, and dams. This carp is also still intentionally stocked in aquaculture facilities; however, it must be stocked in the **triploid** form, which means it is sterile and unable to reproduce. Some states require a permit to stock the carp, and stocking is only permitted in ponds to prevent its spread through waterways and river systems.

## Distribution

Native to eastern Asia, including China and Russia, the grass carp was introduced in many countries for aquaculture plant control. It is now widespread in 45 states in the U.S., including all Mid-Atlantic states. Reproductively sterile **triploid** grass carp can be stocked in Delaware, New Jersey, New York, Pennsylvania, Virginia, West Virginia, and North Carolina with a permit. In Maryland, use of **diploid** or **triploid** grass carp is prohibited.



## Impacts

While the grass carp does help to reduce unwanted aquatic vegetation, it also alters the food web because it feeds voraciously on desirable plant species, reducing the amount of food available to native invertebrates and fishes. Excreted plant material can also increase nutrient levels in the water that cause harmful algal blooms and affect water quality.

United States Distribution



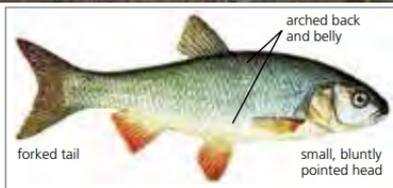
# Ide

*Leuciscus idus*



## Species at a Glance

The ide, also called the orfe, is a large-bodied freshwater fish and member of the minnow family. It is valued as a sport fish in many countries and has been introduced to a number of locations for this purpose. Concerns have been raised over its potential to damage native aquatic ecosystems, but more research is needed to determine actual impacts.



## Identification

This chunky fish has a distinct arch in the back and belly. The head is small and bluntly pointed and the tail has a fork in it. Two color forms exist, including the wild form and ornamental form. The wild form is a grayish-olive color on the back and upper sides, paling to silver on the sides and a silvery-white on the belly. Both **anal** and **pelvic fins** are reddish in color. The ornamental variety has a bright orange back, silver-orange sides and belly, and a bright orange tail and **dorsal** fin. These two color **morphs** are known as silver and golden ides respectively. Golden populations may revert to wild coloration over time.

## Similar Species

This species may be confused with the European rudd (*Scardinius erythrophthalmus*); however the **pectoral**, **pelvic**, and **anal fins** of the rudd are a distinctive bright reddish-orange color. In addition, the iris of the rudd's eye is yellow to orange, often with a red spot that can cover the pupil, which is absent in the ide.

## Habitat

The ide prefers to inhabit clear, clean pools of medium-to-large rivers, ponds, and lakes. It retreats into deep holes over winter. The ide can also tolerate higher levels of salinity, giving it the ability to colonize brackish water and estuarine habitats.

## Spread

Valued as an ornamental pond fish, the ide has been intentionally introduced to new locations for ornamental purposes and angling. Intentional releases and escape by flooding have also allowed this species to move to new locations.

## Distribution

Native to Europe, the ide was first imported in 1877 by the U.S. Fish Commission. In 1889, an estimated 20 ide escaped into the Potomac River from fish ponds in Washington, D.C. during a flood event. The ide is established in the Mid-Atlantic in the lower Potomac River in Maryland, and it has also been collected in Virginia and West Virginia. Failed populations have also occurred in New Jersey, New York, North Carolina, and Pennsylvania.



## Impacts

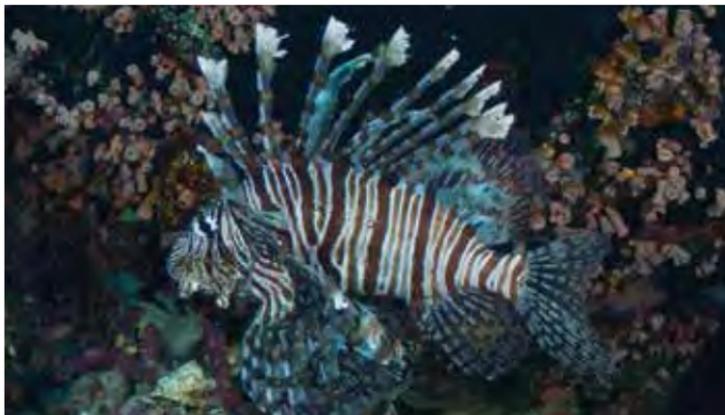
Like other members of the minnow family, the ide is a prolific breeder and large females may contain tens of thousands of eggs. While little is known about the impact of this species, many researchers believe the ide has the potential to become more of a problem to aquatic ecosystems than either goldfish or common carp.

United States Distribution



# Lionfish

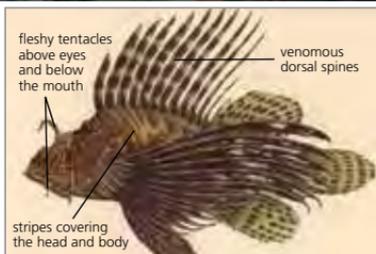
*Pterois volitans* and *P. miles*



## Species at a Glance

The red lionfish (*Pterois volitans*) and the devil firefish (*P. miles*) are species of invasive lionfish that were introduced by humans and are now causing negative impacts on marine ecosystems

and reef habitats. Their venomous spines and unique appearance may deter potential predators, making them unrecognizable as prey and allowing their populations to increase.



## Identification

Lionfish have distinctive brown or maroon and white stripes covering the head and body that alternate from wide to very thin and sometimes form a "V"-shape. They have fleshy tentacles above the eyes and below the mouth. Membranes of the fins are often spotted. The **pectoral fins** are fan-like, while the strong, venomous **dorsal spines** are long and separated. The **anal fin** also has sharp venomous spines. Adult lionfish can grow as large as 46 cm (18 in) while juveniles may be as small as 2.5 cm (1 in) or less.

## Similar Species

In their native range, the red lionfish and the devil firefish can be differentiated by counting the fin rays; however, in their invasive range, these two species can be virtually identical and positive identification can only be achieved through genetic analysis.

## Habitat

While found in almost all marine habitat types, lionfish prefer warm marine waters of the tropics. They have been found in water depths from 0.3-305 m (1-1000 ft) on hard bottoms, mangroves, seagrass, coral, and artificial reefs.

## Spread

Initial introduction of both species was thought to have occurred during Hurricane Andrew in 1992 when at least six lionfish escaped from a broken beachside aquarium near Biscayne Bay. The continued release of unwanted lionfish by aquarium hobbyists is thought to be the cause of additional introductions and the range expansion of the lionfish.

## Distribution

Lionfish are native throughout the South Pacific and Indian oceans and their native distribution covers a very large area. They were first detected in south Florida waters in 1985 and were documented as established in the early 2000s. They are now well established throughout most of the Caribbean to Cape Hatteras, North Carolina. Juveniles have also been found as far north as New York and Rhode Island, although they are not expected to be able to survive the winter in colder northern waters.



## Impacts

The lack of natural predators is allowing lionfish to reproduce year round and quickly increase in abundance. They are voracious predators, consuming over 50 species of fish, including some economically and ecologically important species.

They pose a threat to many native reef fish populations through direct predations as well as competition for food and resources. They can also reduce the abundance of herbivorous fishes that keep seaweeds and macroalgae from overgrowing corals.



## Northern Snakehead and Blotched Snakehead

*Channa argus* and *Channa maculata*

---



### Species at a Glance

Northern and blotched snakeheads are freshwater obligate air breathers that possess an air bladder that works like a primitive lung, allowing them to survive out of water in moist locations for several days. While other species of snakehead have been known to wriggle short distances over wet lands to new bodies of water, this behavior has not been documented for this species. These adaptations may give snakeheads a competitive edge in securing habitat and expanding their range.

### Identification

Snakeheads have a long, torpedo-shaped body that can grow to a maximum size of 85 cm (33 in). The **dorsal** and **anal fins** are long and continuous, running along the top and bottom of the body and nearly reaching the **caudal fin**. As the name implies, the scaled head of the fish looks like a snake. The mouth is large with sharp teeth, and a **truncate** (not rounded) tail. Coloration is generally tan to black with irregular blotches or spots along the sides.



## Similar Species

The native bowfin (*Amia calva*) is often mistaken for snakeheads. The bowfin is distinguished by a rounded tail, scaleless head, and an eyespot near the tail in males. The burbot (*Lota lota*) can be distinguished by its split **dorsal fin** and a single barbel on the lower jaw. The **dorsal** and **anal fins** of the bowfin and burbot are also short in comparison to snakeheads. Northern and blotched snakeheads look very similar to each other, although the blotched snakehead generally has dark bar-like marks preceded by pale bar-like areas. These species also differ in the number of scales in the **lateral line**, as well as rays in the **dorsal** and **anal fins**.

## Habitat

Most snakeheads can be found in streams and rivers and both the northern and blotched snakeheads prefer stagnant shallow ponds, swamps, and slow streams with mud or vegetated substrate. They can tolerate low oxygen conditions, and survive in waters that are covered in ice.

## Spread

The sale of live snakehead in pet shops and live food-fish markets in the United States may have contributed to their introduction. When they grow too big for aquarium tanks, uninformed pet owners may release them into the wild. In addition, they have also been released as part of religious or cultural practices. In 2002, the import and interstate transport of the northern snakehead was banned without a permit from the U.S. Fish and Wildlife Service.

## Distribution

Native to China, Russia, and Korea, the first reported breeding population of the northern snakehead in the United States was discovered in a pond in Crofton, Maryland in May 2002. It can now be found in many other Mid-Atlantic states including Pennsylvania, Virginia, New York, Delaware, and New Jersey. The blotched snakehead, while not yet confirmed as established on the mainland, has been established in Hawaii since the 1800s, and single individuals have been collected in North Carolina and Massachusetts.



## Impacts

While impacts of the blotched and northern snakeheads remain unknown, these species have the potential to compete directly with native species for food and habitat. They may also prey directly on native fish, crustaceans, frogs, small reptiles, and sometimes even small birds and mammals, although adults feed almost exclusively on fish, and such impacts have yet to be documented. Similarly, no adverse impacts on managed populations of introduced sport fishes (e.g., largemouth bass) have been documented to date.



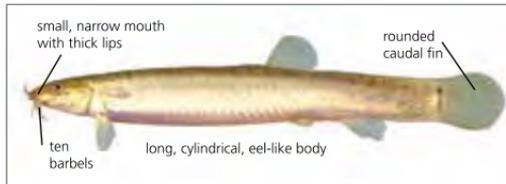
# Oriental Weatherfish

*Misgurnus anguillicaudatus*



## Species at a Glance

The oriental weatherfish, also called the dojo



and Chinese loach, is a small eel-like fish that gets its name from its ability to “forecast the weather”. It is sensitive to changes in barometric pressure, so increases in activity and swimming in fast circles can indicate that major weather changes are imminent. This species is also popular in the aquarium trade because it is hardy and has a voracious appetite that can help keep tanks clean. Unfortunately, the release of this species into natural waterways has caused negative impacts to water quality, native species, and the food web.

## Identification

The oriental weatherfish has a long, cylindrical, eel-like body with greenish-gray-brown marble markings on the dorsal side, and pale silver sides and underbelly. Many specimens have a large pigmented spot located above the base of the **caudal fin**. The mouth is small and narrow with thick, fleshy lips surrounded by ten barbels. The **lateral line** is short and doesn’t extend past the pectoral fin. The pectoral fin has a stout spine, and the **caudal fin** is rounded. Average size is up to 28 cm (11 in). This species exhibits sexual size **dimorphism**, with the average length of the female being considerably larger than that of the males.

## Similar Species

Because of its eel-like body, the oriental weatherfish may be confused with species of lamprey; however, lamprey are typically thinner and don't have the characteristic barbels on the mouth.

## Habitat

This species is very hardy and can survive a wide range of temperatures and environmental conditions. It is typically found in slow or still waters with muddy or silty bottoms abundant with aquatic plants. It feeds on bottom-dwelling animals, insect larvae, snails, and worms. The oriental weatherfish can breathe atmospheric oxygen by using its intestine as an accessory respiratory organ, allowing it to live in oxygen-poor waters and to bury itself in soft substrates to survive long droughts.

## Spread

Commonly used as bait and sold in the aquarium trade, the oriental weatherfish is released when aquariums are dumped, or when bait buckets are emptied. Its popularity as a food-fish is also linked with its purposeful introduction into the wild to create harvestable populations.

## Distribution

Native to Eastern Asia, the oriental weatherfish was most likely introduced to natural waters in the United States by fish farm and aquarium escapes. It is found in both eastern and western parts of the United States, and has established in drainages in New York, New Jersey, and North Carolina in the Mid-Atlantic.



## Impacts

The oriental weatherfish can negatively impact native species by predation and competition for food, habitat, and spawning sites. It can also increase **turbidity** and nitrogen levels in standing water, which can negatively impact water quality.



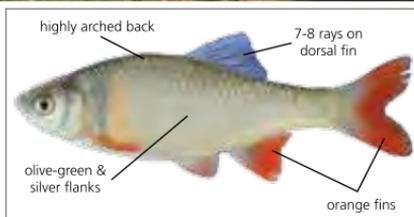
# Red Shiner

*Cyprinella lutrensis*



## Species at a Glance

The red shiner is in the genus *Cyprinella*, which is Greek for “small carp”. While this hardy, widespread shiner is native to the Midwestern U.S., its use as a baitfish has allowed its introduction into habitats outside of its native range.



## Identification

The red shiner is a deep-bodied species with a highly arched back. Its **flanks** are mixed olive-green and silver, with bright orange fins and a large orange spot that sits between the eyes on its blunt, sloped brow. Spawning males become bluish on the sides and the fins redden. There are 7-8 rays in the **dorsal fin** and 8-10 (usually 9) rays in the **anal fin**. Maximum size is only 9 cm (3.5 in). The red shiner can crossbreed with other minnow species, such as the blacktail shiner (*Cyprinella venusta*) and the endangered blue shiner (*Cyprinella caerulea*), producing hybrids that may also have a faint **caudal** spot.

## Similar Species

While easily confused with most other minnows, including the golden shiner (*Notemigonus crysoleucas*), the redbfin shiner (*Lythrurus umbratilis*), the rudd (*Scardinius erythrophthalmus*), and the roach (*Rutilus rutilus*), the outstanding characteristics of the red shiner are the vibrant orange fins and the orange spot between the eyes.

## Habitat

While it's found in a variety of habitats, the red shiner prefers silt disturbed streams and muddy riverbeds where it doesn't have to compete with other minnows for food.

## Spread

The red shiner was most likely introduced through intentional release from both recreational fishing and more recently, through the aquarium trade. Its extended mating season, coupled with the versatile nature of the eggs, allows this species to spread quickly throughout habitats.

## Distribution

The red shiner is native to a large portion of the U.S. Midwest, reaching from central North Dakota to the southernmost point of Texas along the Mississippi River and its tributaries. Currently, the red shiner is established in the Mid-Atlantic region in Virginia and North Carolina.



## Impacts

Known to eat small invertebrates, the red shiner is in direct competition with native fish and invertebrates for food. The red shiner also has adaptive advantages over other cyprinids because it can lay eggs in tight crevices and attach adhesive eggs to rocks and plant life.



# Round Goby

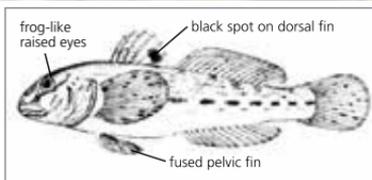
*Neogobius melanostomus*



## Species at a Glance

The round goby is a small, aggressive, bottom-dwelling fish that has altered the Great Lakes food web since it was first

discovered in Lake St. Clair in 1990. It grows rapidly and reproduces several times in one season. Avian botulism outbreaks appear directly related to the round goby due to its heavy feeding on invasive zebra and quagga mussels.



## Identification

The two most distinguishing features of the round goby are the black spot on the **dorsal fin**, and the fused **pelvic fin** that forms one suction cup-shaped fin. Young round gobies are a solid slate gray, whereas older gobies are mottled with olive green, black, gray, and brown spots. Spawning males turn almost solid black. It has a soft body and a large round head with very distinctive frog-like raised eyes. On average, it grows 10 -25 cm (3.9-9.8 in) in length.

## Similar Species

While the round goby looks very similar to the native mottled sculpin (*Cottus bairdi*), the sculpin has two separated **pelvic fins** and lacks the black spot on the **dorsal fin**. The round goby may also resemble the much smaller, invasive tubenose goby (*Proterorhinus marmoratus*), but the tubenose goby has tubular-shaped nostril extensions and lacks the protruding eyes and the black spot on the first **dorsal fin**.

## Habitat

This freshwater fish prefers shallow water with rocky and sandy bottoms where it likes to perch on top of rocks and hide in crevices. The round goby can occupy a variety of depths and can tolerate a wide range of temperatures, water quality, and oxygen concentrations. It can also survive in brackish water.

## Spread

The round goby was most likely introduced to the Great Lakes through the ballast water of ocean-going cargo ships. Because it resembles small baitfish, boaters and fishermen can accidentally carry it from one body of water to another through bait buckets, bilge water, and plant debris.

## Distribution

Native to Eurasia, including the Black, Caspian, and Azov seas and tributaries, the round goby was first sighted in the St. Clair River in 1990 and has since spread to all of the Great Lakes. It is now working its way inland through rivers and canal systems and can be found in the Mid-Atlantic in select locations in New York and Pennsylvania.



## Impacts

The round goby is thriving at the expense of native populations, many of which are important sport fish. It outcompetes native species including sculpin, logperch, lake trout, and darters for food sources, habitat, and spawning sites. It also spawns more frequently than its native competitors, and feeds directly on their eggs and young.



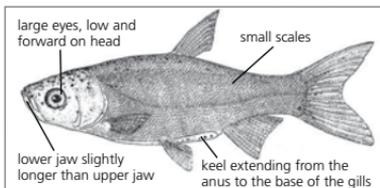
# Silver Carp

*Hypophthalmichthys molitrix*



## Species at a Glance

The silver carp is a member of the Asian carp complex, which includes bighead, black, and grass carp. While it is not yet found in the Mid-Atlantic region, its large size, voracious appetite, and ability to leap out of the water make it an enormous threat to the region's fisheries and recreational economies.



## Identification

This very large filter feeder averages 40-70 cm (16-28 in) in length, but can reach up to 130 cm (51 in) and weigh up to 36 kg (80 lbs). Its deep body is **laterally compressed**, with a **ventral keel** that extends forward from the anus almost reaching the base of the gills. Large eyes are located low and forward on the head. The mouth is large and **terminal** and the lower jaw is slightly longer than the upper jaw. No barbels are present on the mouth. The short **dorsal fin**, which lacks spines, contains 7-10 rays. Scales are very small. Coloration is olive to grayish-black on the back, with silvery sides blending to white below, and darker pigmentation on the fins.

## Similar Species

While it most closely resembles the invasive bighead carp (*Hypophthalmichthys nobilis*), the silver carp is fairly uniform in color, lacking the irregular dark blotches found on the back and sides of the bighead carp. The bighead carp also has a less extensive **keel**, spanning from the **pelvic fin** to the **anal fin**. Silver carp may also resemble the common carp (*Cyprinus carpio*), which has barbels on either side of the mouth, and species of suckers (*Catostomidae*), which have thick lips containing small nipple-like bumps.

## Habitat

The silver carp is an exclusively freshwater fish, preferring large river systems, lakes, or impoundments with flowing water needed for spawning. It can feed in temperatures as low as 2.5°C (36.5°F) and can withstand low levels of oxygen.

## Spread

Once introduced to open waters, the silver carp readily spawns and disperses. Because juveniles resemble some common baitfish species, it may be unintentionally spread through the use of live bait. It can also spread in illegal shipments of live Asian carp, which is popular in the Asian food market.

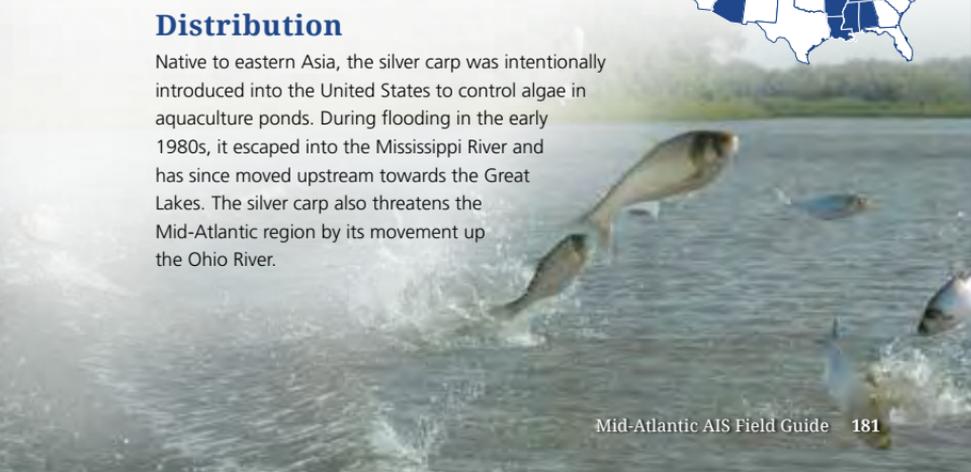
## Distribution

Native to eastern Asia, the silver carp was intentionally introduced into the United States to control algae in aquaculture ponds. During flooding in the early 1980s, it escaped into the Mississippi River and has since moved upstream towards the Great Lakes. The silver carp also threatens the Mid-Atlantic region by its movement up the Ohio River.



## Impacts

The silver carp consumes vast amounts of plankton and **detritus** each day, competing with native filter feeders and juvenile fish for food. In addition, when startled by boat motors or other equipment, the silver carp can leap up to 3 m (10 ft) out of the water, posing a risk of injury to boaters and watersport enthusiasts.



# Tubenose Goby

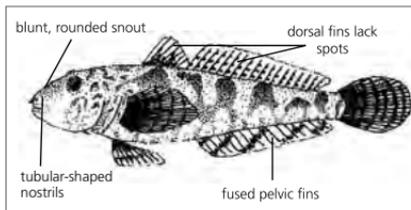
*Proterorhinus semilunaris*



## Species at a Glance

The tubenose goby is a small, bottom-dwelling fish that gets its name from its tubular-shaped nostrils. It feeds mainly on aquatic

insects and although females can live for up to five years, males die immediately after spawning.



## Identification

Its cylindrical body has small scales and a somewhat flattened underside, measuring 6-11 cm (2.4-4.3 in). It has a blunt and rounded snout with a wide mouth and large lips. Tubular-shaped nostrils extend just beyond the tip of the snout. Two **pelvic fins** are fused into a single suction cup-shaped fin, and the two **dorsal fins** lack spots. The body is light brown with darker brown blotches that can form vertical bars on the rear half of the sides. A triangular black spot is present at the base of the **caudal fin**, followed by two white spots.

## Similar Species

While it may be confused with the round goby (*Neogobius melanostomus*), the tubenose goby is much smaller than the round goby and has tubular-shaped nostril extensions. The round goby has a black spot on the first **dorsal fin** and has very distinctive frog-like eyes that protrude from the top of the head. In addition, the tubenose goby does not feed on zebra mussels and its mouth is too small to be caught on fishing lines like the round goby. The tubenose goby may also be confused with the native sculpin; however, the sculpin does not have scales or **pelvic fins** that form a suction cup.

## Habitat

The tubenose goby lives in slightly brackish to freshwater. It actively defends nest sites created under rocks, logs, and shells in shallow areas of lakes and rivers with plenty of plant cover.

## Spread

The tubenose goby was most likely introduced to the Great Lakes in the ballast water of ocean-going ships. Since it often resembles small bait fish, it can also be spread by boaters and fishermen who accidentally carry it from one body of water to another through bait buckets, bilge water, and plant debris.

## Distribution

Native to the Black and Caspian seas in Europe, the tubenose goby was first found in Lake Erie around 1990 and can now be found in lakes St. Clair, Erie, and Superior. There are currently no inland or Mid-Atlantic occurrences of this species other than the Great Lakes portion of Pennsylvania.



## Impacts

While its impacts are not yet known, the tubenose goby may be able to compete with and prey upon benthic species in a manner similar to the larger round goby. However, because it is small and not as aggressive, the tubenose goby may not be as detrimental as the round goby.

United States Distribution



# Invasive Pathogens

---



Fish are vulnerable to a variety of diseases caused by pathogens such as bacteria, viruses, and fungi that are a normal part of their environment.

These pathogens can be present at low levels, yet fish can remain healthy if their immune system is strong.



Hemorrhaging caused by viral hemorrhagic septicemia (VHS) virus

Disease outbreaks occur when fish are stressed by poor diet or sudden environmental changes that weaken their immune system, allowing the pathogens to be more active. Outbreaks also occur when fish are exposed to new pathogens to which the fish has limited immunity.

Like human diseases, fish diseases are infectious; once a few fish get sick, the pathogens can spread rapidly in water, from fish to fish, causing large die-offs in the population.

Only a fish disease expert can identify with certainty which pathogen is causing a disease. Diseases may affect fish in different ways and many of them have similar and overlapping symptoms.

Common warning signs of a fish disease outbreak include:

- Abnormal swimming; swimming in circles or upside down
- Gasping, rapid gill movement; bleeding, eroded, or pale gills
- Skinny body, hollow belly
- Pale body colors
- External cysts, sores, bloodstains; bloody or bulging eyes
- Fungus, often resembling white or yellow fuzz, on body



Bulging eyes, a symptom of fish disease

If you see fish exhibiting any of these symptoms, contact state and federal authorities immediately. See the "Collecting and Reporting" section for more information on reporting suspected cases.



# Common Pathogens

---



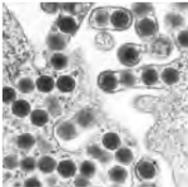
**Chytrid Fungus** (*Batrachochytrium dendrobatidis* [Bd]): The fungus “Bd” is a member of a phylum of primarily aquatic fungi called Chytridiomycota, some of which are parasitic. Bd infects living amphibians (primarily frogs) and causes the disease known as amphibian chytridiomycosis. This disease is believed to be a major cause of global amphibian declines and extinctions. It is currently found on every continent where amphibians exist and is actively spreading to new populations. This disease interferes with essential processes that allow amphibians to take up water through their skin to breathe. Infected frogs may become lethargic, they are often unable to right themselves if turned upside down, and they may jump or swim in circles. In addition, the skin appears bloodshot and they may sit out in the hot sun when healthy frogs would seek shelter. Some species of frog, such as the African clawed frog, appear resistant to the disease, although they can still be carriers and move the fungus to new locations. A second species of *Batrachochytrium*, *B. salamandrivorans* (Bs), has emerged as a new amphibian disease agent affecting salamanders in Europe. The U.S. Fish and Wildlife Service has banned the importation of salamanders from Europe to prevent introduction of this disease organism to North American salamander populations.



**Eel swimbladder nematode** (*Anguillicola crassus*): Native to Southeast Asia, the eel swimbladder nematode is a small, 3 cm (1.2 in) long parasite that is currently found in the United States in New York, Delaware, Maryland, North Carolina, South Carolina, and Florida. This species uses the Japanese eel (*Anguilla japonicas*), European eel (*A. anguilla*) and the American eel (*A. rostrata*) as hosts. Eggs hatch inside the eels, and as larvae emerge they are released into the water from the host intestine. Larvae survive in a free living stage until they are ingested by crustacean intermediate hosts, which are then consumed by the eels. With American eel populations already declining, the introduction of this nematode may have a large negative impact on survival of this species. Symptoms include reduced swimming ability, rendering the eel vulnerable to predators, reduced growth rate, and mortality.



**Largemouth bass virus (LMBV)** (*Iridoviridae*): This virus is from the family *Iridoviridae* and is known to cause lethal disease to wild, adult largemouth bass (*Micropterus salmonides*) in the eastern United States. Disease usually occurs during warmer months in the summer when bass are physically stressed. When the virus causes disease, symptoms may include increased blood flow and darkened skin, distended abdomen, bloated swim bladder, lesions in the membrane lining the body cavity, pale liver, red spleen, infected gills, lethargic swimming, decreased responsiveness, swimming at the surface and/or in circles, difficulty remaining upright, and death. LMBV is easily transferred from one infected bass to another, and among several other species of fish including sunfish and snakeheads. The virus has not reportedly caused disease in any other species except largemouth bass. Cases of disease and mortality are usually followed by individuals developing antibodies, allowing the population to recover within five to seven years. Many bass that carry LMBV may never develop disease and appear completely normal. LMBV does not infect warm-blooded species.



**Ranavirus:** The genus *Ranavirus* is a genus of highly infectious viruses that are found worldwide and are often lethal to aquatic and terrestrial cold-blooded wildlife. They can cause mass-die offs of fish, amphibians (frogs and salamanders), and reptiles (turtles and snakes). While not all species are susceptible, more than 104 species were documented with the virus in 2013. Clinical signs of the disease include swelling of the legs and body, internal **hemorrhaging**, redness of the legs and vent, and discoloration of internal organs. White plaque in the mouth, wheezing, and swollen eyes are additional symptoms that might be present in reptiles. Behavior changes may include lethargy, anorexia, and erratic swimming. Ranaviruses are primarily transmitted by direct contact between a carrier and uninfected individuals. Depending on environmental conditions, the viruses can survive in water for several weeks outside the host, and for shorter periods of time under dry conditions. Drying may also inactivate the viruses, therefore drying of recreational boats, trailers, fishing equipment, and other gear after use is important for preventing their spread.

## Common Pathogens *Cont.*

---



**Spring Viremia of Carp (SVC)** (*Rhabdovirus carpio*): SVC is a bullet-shaped RNA virus that can cause severe disease outbreaks in members of the *Cyprinidae* family, such as common carp. SVC usually occurs in the spring when water temperatures are less than 18°C (64°F). Symptoms include bulging eyes; **hemorrhaging** of the skin, gills, and eyes; a bloated appearance; darkening of the skin; and vent protrusion. Diseased fish may appear lethargic, swim and breathe more slowly than normal, and gather at the water inlet or sides of ponds. This highly contagious disease can be spread through contact with feces, urine, gill and skin mucous, and through parasitic invertebrates such as the carp louse or leeches. While fish can carry SVC with or without symptoms, there is no vaccine for the virus and outbreaks can cause high rates of death and substantial economic losses.



**Viral Hemorrhagic Septicemia (VHS)** (*Novirhabdovirus sp.*): VHS is a bullet-shaped virus that was discovered in the Great Lakes region as early as 2003, causing significant fish kills in the United States and Canada. Different strains of VHS are present in different regions of the world, with “4b” being the strain impacting the Great Lakes. Symptoms of the disease include bulging eyes, bloated abdomens, darker coloration, unusual behavior, and **hemorrhaging** in the eyes, muscle tissue, skin, gills, and at the base of the fins. Some species of fish are carriers of the virus, but show no obvious symptoms. Mortality is highest at water temperatures between 9-12°C (48-54°F) and death rarely occurs at temperatures above 15°C (59°F). VHS is highly contagious and is spread through contact with infected water or from fish to fish. At least 50 species of marine and freshwater fish carry the virus, and survivors can be lifelong carriers.



**Whirling Disease** (*Myxobolus cerebralis*): Whirling disease is an infection caused by the microscopic parasite *Myxobolus cerebralis*, which impacts members of the *Salmonid* family. *M. cerebralis* is an invasive species from Europe that can cause fish to swim in a characteristic “whirl” pattern. The parasitic organism has a complex life cycle requiring tubifex worms and the *Salmonid* family of fish to complete. It begins when tubifex worms consume spores found in the sediment of river bottoms which develop into a free-swimming form called **triacinomyxon** (TAM). Tam spores are released into the water and attach and penetrate through the fish’s skin. The TAM spores then multiply rapidly and invade the spinal cord and brain, causing the fish to “whirl”. Other symptoms include blackened tail and deformities of the head and spine. When an infected fish dies, millions of parasite spores can be released into the water to begin the cycle again.

# Algae Group Descriptions

---



**Green algae** (*chlorophyta*): This large and diverse group of algae can range from small single-celled organisms to large multi-cellular organisms and colonies. They are considered the closest ancestors to the land plants because they share common features, including the **photosynthetic** pigments chlorophyll a, chlorophyll b, beta carotene, and cellulose-rich cell walls. They are also the only algal group to produce starch for food stores.



**Cyanobacteria** (*cyanophyta*, historically referred to as blue-green algae): Notorious for forming blooms (some of which are toxic), these organisms are not really algae, but rather aquatic bacteria that obtain their energy through **photosynthesis**. Like other bacteria, the cells are **prokaryotic** and therefore lack nuclei, **chloroplasts**, mitochondria, and **flagella**. **Cyanobacteria** may be single-celled or colonial, with colonies forming filaments, sheets, or even hollow balls.



**Golden-brown algae** (*chrysophyta*): Mostly abundant in freshwater, this large group of algae is typically found in waters with a neutral or slightly acidic pH, low conductivity and nutrient levels, and colder temperatures. They are particularly important in lakes, where they may be a primary source of food for zooplankton. In many species, the cell walls are composed of cellulose with large quantities of silica, similar to the diatoms.



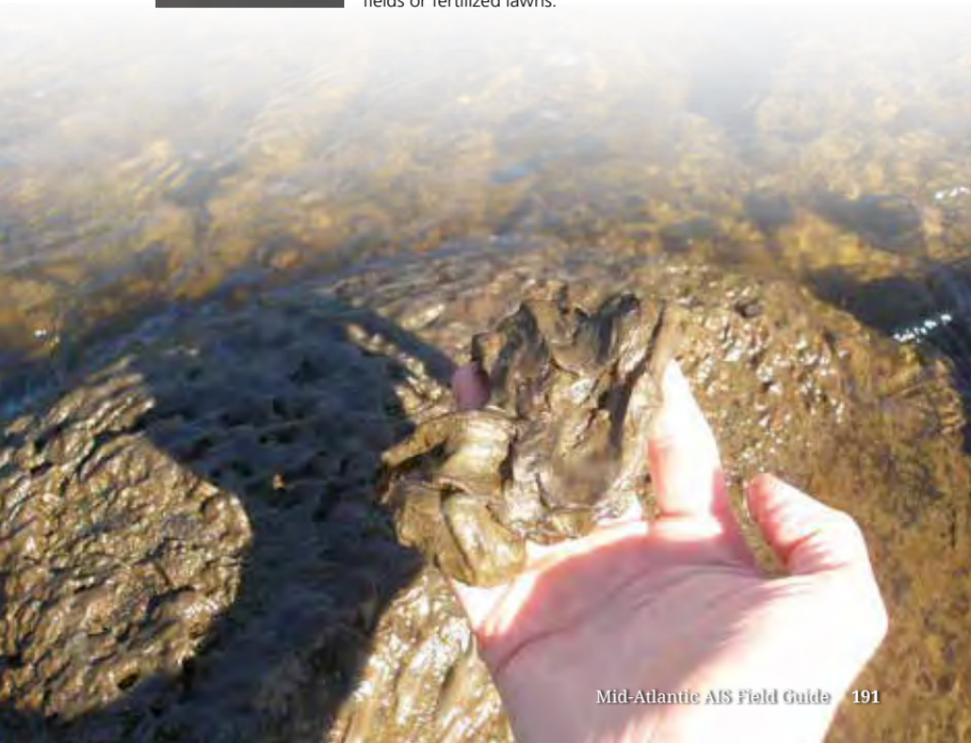
**Dinoflagellates**: These typically unicellular **flagellates** have armored cell walls made of thick plates that fit tightly together to form a continuous covering for the cell. Half the dinoflagellates are colorless predators that consume their food. The other, pigmented half are usually a golden brown in color. Out of the several thousand species of dinoflagellates, only a couple hundred are found in freshwater habitats.



**Diatoms:** These single-celled organisms are characterized by beautiful and intricate shapes. Most diatoms exist singly, although some join to form colonies. Diatoms can be fresh or salt-water and appear in the greatest abundance early in the year in the phenomenon called the “spring bloom,” when both light and nutrients are highly available. The cell walls are made up of silica, which persists in the environment after the cells have died, creating an extensive fossil record.



**Euglenoids:** This small phylum consists of mostly freshwater, unicellular aquatic algae. Some euglenoids contain **chloroplasts** with **photosynthetic** pigments, and others are heterotrophic, meaning they can ingest or absorb their food. The most characteristic genus is *Euglena*, common in ponds and pools, especially when the water has been polluted by runoff from fields or fertilized lawns.



# Black Mat Alga

*Lyngbya wollei* (*Plectonema wollei*)

---



## Species at a Glance

Black mat alga is a hardy, quickly multiplying, toxic **cyanobacterium** that masquerades as a filamentous blue-green alga. It is considered the prehistoric “beast of water algae” because of its potentially deadly impacts. It forms large benthic and floating mats that have been shown to degrade water quality, aquatic habitats, and produce dangerous toxins.

## Identification

Colonies of clustered filaments, usually visible to the naked eye, form dense dark green to black mats along the bottom of the water. These mats remain inconspicuous until they are either dislodged by wave or wind action, or gasses produced during **photosynthesis** become trapped underneath and allow them to float to the surface. The mats start out looking like brown smoke in the water and as they surface, they ball up into the shape of marbles with the texture of coarse hair. The algae filaments are unbranched, untapered, and are encased in **sheaths**. Cells have been observed at 2-12  $\mu\text{m}$  in length. While lacking specialized cells, this alga is still able to fix nitrogen from the atmosphere.

## Similar Species

May be difficult to distinguish from *Phormidium*, which also forms mats that can be dark brown, green, purple, or blue-green. *Phormidium* has short cylindrical cells in a fine **sheath**. Cells are at least as long as they are wide and the ends of the cell often taper with a thickened “cap” at the end.

## Habitat

While it thrives in warm, slightly alkaline waters with abundant nutrients, black mat alga is found in a wide range of habitats, from clear, mineralized, thermally and chemically stable water bodies in Florida, to **turbid** waters with variable nutrients in the St. Lawrence River. It is highly resistant to freezing and cold weather, and is also able to survive without light once established.

## Spread

Black mat alga grows in sediments and rapidly multiplies in warm water. The stringy filaments can cling to fishing gear, boats, trailers, and other recreational equipment and get moved to new locations where mats can persist for several years.

## Distribution

Commonly found in ponds and lakes in the southeastern United States, a genetically similar subgroup of algae has been proliferating in the Great Lakes Region and the St. Lawrence River. Many believe black mat algae arrived in these locations because the chemistry and water temperature changed, or it arrived on recreational boats. This alga is also found in locations in North Carolina, Virginia, and the northern Chesapeake Bay area of Maryland.



## Impacts

Black mat alga is considered a harmful **cyanobacterium** because of its ability to smother native vegetation, negatively impact fish communities, and produce toxins that are a threat to livestock, dogs, and other animals. In humans, the toxins have caused skin irritations, allergic reactions, gastrointestinal symptoms and respiratory problems. These toxins are responsible for a musty-earthy taste and odor in water, which can affect aesthetics and recreational water uses. It's also nearly impossible to control with current physical, chemical, and biological tools.



# Codium

*Codium fragile* ssp. *tomentosoides*



## Species at a Glance

Codium, also referred to as the “oyster thief”, has been introduced around the world through shellfish aquaculture, recreational boating, and ballast water transport. It will often make its home on the shells of oysters, scallops, and clams, smothering them and causing damage to aquaculture industries. Codium is also a nuisance when it accumulates and rots on beaches, producing a foul odor.

## Identification

A large, dark green, branching alga that can reach up to 1 m (3 ft) in length and weigh up to 4 kg (8 lbs). In wave exposed areas, it tends to be shorter as it undergoes more frequent **fragmentation**. Codium is composed of cylindrical, **dichotomous**, spongy branches that are 3-10 mm in diameter. A spongy **basal** holdfast anchors the plant to hard objects. The cortex of the alga is formed of club-shaped, bladder-like swellings called **utricles** that are tightly compressed together. The alga is upright when small, but droops as it gets larger. Juvenile stages appear as fuzzy, moss-like mats. Codium bleaches white when washed onto shore.

## Similar Species

While *Codium* is often mistaken for a sponge, there are no native sponges in the northwest Atlantic Ocean with a similar appearance to this alga. While it's difficult to distinguish the different subspecies of *Codium*, it can be done by looking at variations in the size and shape of the **utricle**s.

## Habitat

Able to colonize a wide range of environments, *Codium* tolerates large variations in salinity and temperature. It thrives in sheltered habitats such as harbors, estuaries, and bays and generally prefers to attach itself to hard surfaces such as rocks, ropes, jetties, wharf pilings, and shellfish.

## Spread

*Codium* was most likely introduced through ballast water, hull fouling, aquaculture, and through its use as a packing material for shipping live marine organisms. Once introduced, it has multiple methods of reproduction that can help it establish and spread, including sexual reproduction, **parthenogenesis**, and **fragmentation**. Water currents can also carry this species over long distances, introducing it to new locations.

## Distribution

Native to coastal Japan, *Codium* has established itself worldwide. On the East Coast of North America, it is found from the Gulf of Saint Lawrence in Canada, down to South Carolina and in all Mid-Atlantic states except for Pennsylvania.



## Impacts

Considered a fouling organism, *Codium* causes problems when it attaches itself to shellfish beds, fishing nets, and other man-made structures. This alga can smother the shellfish it rests upon, and can float away with oysters attached to it. It can also impact the benthic environment by making it difficult for invertebrates and fish to move among it and forage on the ocean floor. It has been known to displace native kelp forests and can therefore disrupt the food web in these habitats.



# Didymo

*Didymosphenia geminata*



## Species at a Glance

Didymo, also called “rock snot,” is a single-celled diatom alga found in the cool waters of northern Europe and North America. Since the mid-1980s, it has begun to take on the characteristics of an invasive species, releasing **stalk** material when conditions are right that form massive blooms that can blanket stream and river bottoms, threatening a variety of aquatic systems.

## Identification

Beginning as small circular brown blotches on rocks and other substrates, didymo can grow in two **stalked** forms – short-**stalked** and long-**stalked**. The short form generally appears as a coating on hard substrates, while the long-**stalked** form can take on the appearance of wet fiberglass or toilet paper. Didymo has also been mistaken for raw sewage. The external cell wall is made of silica and is capable of producing the extracellular **stalk** material that forms thick nuisance mats that can be over 20 cm (8 in) thick. While it appears slimy, it is actually rough to the touch, feeling like wet wool or cotton and is very difficult to pull apart and detach from rocks.

## Similar Species

To determine whether a suspect specimen is didymo, squeeze out as much water as possible and rub it between your fingers. Unlike other species of algae, didymo does not break apart when rubbed between your fingers, nor does it feel slimy to the touch. Only microscopic examination can confirm the identity of didymo over other **stalk-forming diatoms** such as *Gomphoneis* and *Cymbella*.

## Habitat

Didymo is both **epilithic** (attaching to stones) and **epiphytic** (attaching to plants) and can thrive in a wide range of physical and chemical conditions within lakes and rivers. It prefers relatively shallow, clear, moderately-flowing and nutrient-poor waters with rocky substrates and plenty of sunshine. Nuisance blooms are only known to occur in flowing water or where there is plenty of wave action.

## Spread

Anglers, kayakers, canoeists, and boaters can accidentally spread this microscopic hitchhiker when it clings to boats, fishing gear, waders, and boots. Felt-soled waders are especially good at transporting didymo because they can stay wet for longer periods of time, and didymo can survive outside of a stream in a cool, damp environment for at least 40 days. Only one cell is needed for didymo to spread.

## Distribution

Historically, didymo was found in cooler waters in the northern hemisphere and was considered a rare alga in the United States. However, in recent years it has exhibited a much greater tolerance for different water quality conditions and has expanded to diverse areas including parts of Canada, New Zealand, and scattered areas in the United States, including New England, Lake Superior, the western United States, and the Mid-Atlantic region in Maryland, New York, North Carolina, Pennsylvania, Virginia, and West Virginia.



## Impacts

Didymo cells can create large amounts of **stalk material** that form thick mats capable of engulfing a stream bottom, covering substrates, smothering aquatic organisms, and ultimately reducing fish habitat and food. Didymo does not appear to affect the safety of drinking water, does not produce an odor, and while aesthetically unappealing, does not appear to be a threat to human health.



# Golden Alga

*Prymnesium parvum*



## Species at a Glance

Golden alga is a naturally occurring, one-celled, microscopic organism that can be found worldwide on every continent except for Antarctica. Toxins produced by this alga have caused extensive kills of aquatic animals, resulting in severe ecological and economic harm.

## Identification

Golden alga is a tiny organism about the size of a human blood cell. It is very mobile and uses its two “tails,” called **flagella**, to move through the water. A short, stiff, hair-like structure called a **haptone** is used to attach the cell to other cells or objects. A yellow-green, C-shaped **chloroplast** wraps around the middle of the cell and can be seen under a microscope. During a typical bloom, the water turns yellowish, yellowish-copper, or a brownish tea color. Foaming at the surface of the water in areas where there is a lot of wave action is another sign. Exposed fish may swim slow or erratically just below the surface, lie inactively along the bottom in shallow areas, or show no avoidance to human presence. Other visible signs include redness or **hemorrhaging** at the base of the fins, around the mouth area, under the chin, and along the belly.

## Similar Species

The conditions typical of a golden alga bloom may come from other sources and do not always indicate a golden alga bloom.

## Habitat

Generally found in brackish waters, golden alga cells can thrive in a variety of environmental conditions, including a salinity range of 1-40 PSU (Practical Salinity Unit) and a temperature range of 5-35°C (41-95°F). Other factors that affect its growth include phosphorus (P) and nitrogen (N) levels, **cationic** substance levels, and pH. Toxic blooms typically occur at salinity levels of 1-12 PSU, temperatures of 10-25°C (50-77°F), and at fairly high P and N levels.

## Spread

A single drop of water may contain over 2,000 golden alga cells. Unintentional spread may occur by water currents or as cells stick to the feathers or fur of waterfowl and other animals. Under stressful conditions, golden alga is able to form into dormant cysts that can hitchhike to new areas in live wells, bait buckets, recreational boating and fishing equipment, or equipment used during water withdrawals.

## Distribution

First identified in the United States in Texas in 1985, golden alga has since spread to 18 states. In the Mid-Atlantic, it can be found in North Carolina and Pennsylvania, where in 2009, golden alga caused a massive kill spanning nearly 30 miles of Dunkard Creek along the Pennsylvania-West Virginia border.



## Impacts

Golden alga is fast growing, resilient, and uses nutrients more effectively than other kinds of algae. Bloom situations can cause extreme die-offs of native, threatened and endangered species. Serious economic consequences for affected communities have also been well-documented. At-risk waters can include those with high salinities and those being affected by mineral resource extraction, such as natural gas. There is currently no evidence that golden alga has toxic effects on non-gill breathing organisms or humans.



# Red Alga

*Gracilaria vermiculophylla*

---



## Species at a Glance

Thought to be native and widespread throughout the Northwest Pacific Ocean, red alga is primarily used as a precursor for agar, which is widely used in the pharmaceutical and food industries. It is highly tolerant of stress and can grow in a wide variety of conditions, allowing it to outcompete native algae and modify its environment.

## Identification

This red macroalga is cartilaginous, cylindrical, and can grow to lengths of 15-100 cm (6-40 in). It is coarsely branched, resembling a wig, with branches around 2-5 mm (0.08-0.2 in) in diameter. It can be found free-floating in the water, or attached to small stones or shells. Color varies from brown to gray to red, depending on the availability of sunlight. The male reproductive organs are borne in pits (**conceptacles**) that are usually more than 75  $\mu$ m deep, and can be a distinguishing characteristic for identification.

## Similar Species

This species may be confused with brown algae (*Phaeophyceae*) and other *Gracilaria* species. *G. gracilis* is a more distinct red, smaller, more delicate, more sparingly branched, and the male **conceptacles** are usually less than 50  $\mu\text{m}$  deep. Therefore, characterization of reproductive structures is often necessary for correct identification.

## Habitat

Red algae grows in a wide range of temperatures, light intensities, and salinities in both temperate and tropical regions. It is well-adapted to low energy, shallow-bottom bays, lagoons, estuaries, harbors, and inlets where it forms extensive beds and attaches to rocks or pebbles and is often covered with sand and mud. It is also tolerant to stressors such as sedimentation, low nutrients, and desiccation.

## Spread

Growing extensively from fragments, red algae spreads as fragments hitchhike on recreational equipment such as fishing and boating gear, or as they naturally disperse by water currents. Red algae is also a highly efficient recruiter around oyster reefs, as it attaches to the shells and can be moved with oyster shipments to new locations.

## Distribution

Native to the Northwest Pacific Ocean including areas of Japan and East Asia, red algae was first discovered in the Mid-Atlantic region in 2000 in North Carolina. By 2002 it was also found in Virginia growing extensively on gill nets and trawls.



## Impacts

Red alga outcompetes native species of algae, inhibiting their growth and survival.

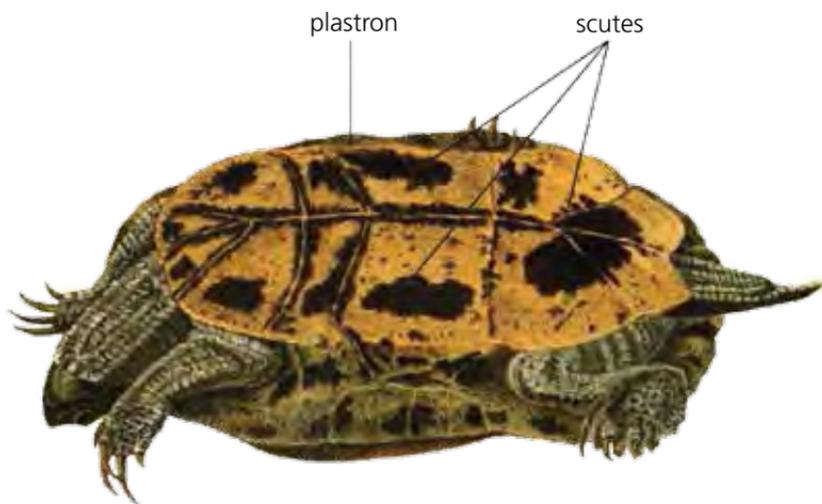
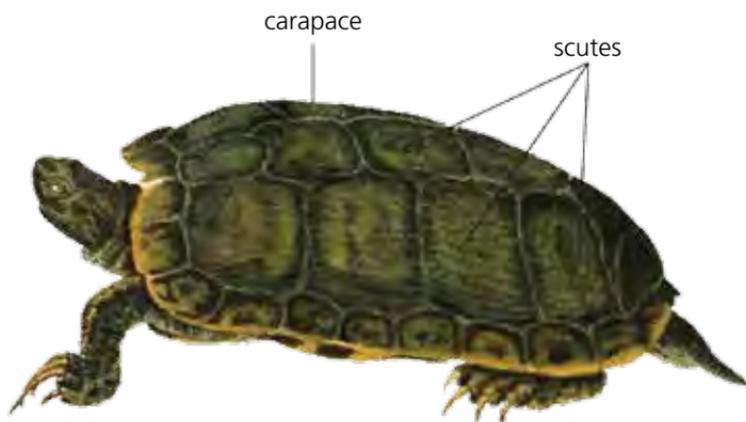
Loose-lying populations can develop into dense mats that modify the habitat available for benthic communities and bottom dwelling fish. These mats can also decrease light intensity, decrease oxygen, and change the pattern of water movements, which in turn affects sedimentation rate and food availability.

United States Distribution

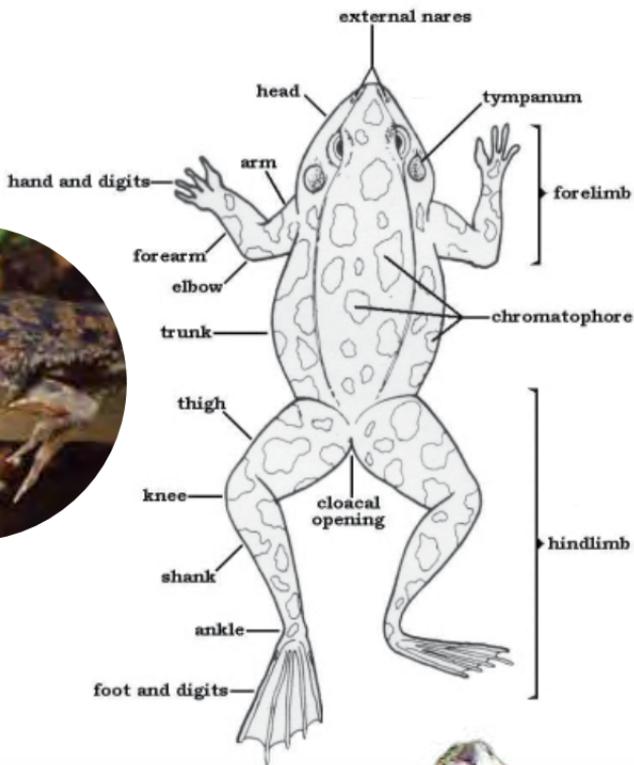


# Turtle Shell Anatomy

---



# Frog Anatomy



# Red-eared Slider

*Trachemys scripta elegans*



## Species at a Glance

The red-eared slider gets its name from the red oblong stripes behind each eye. This medium-sized aquatic turtle has been listed as one of the “100 World’s Worst Invaders” because of its ability to outcompete native turtles for food, resources, and habitat. Its popularity in the pet trade has helped account for its numerous introductions worldwide.



## Identification

A distinctive, broad, reddish-orange stripe runs from behind each eye to the left and right **flanks** of the head. The shell is dark green with yellowish vertical stripes on each **scute**. The skin is olive to brown with vertical yellow stripes or spots. Females typically reach 25-33 cm (10-13 in) in length, whereas males are considerably smaller, reaching 18-23 cm (7-9 in) with a long thick tail and elongated claws on the front feet. The **plastron** has dark smudges on each of its pale yellow **scutes**. Older males often **melanize**, which results in a loss of pattern and color.

## Similar Species

The red-eared slider is most often confused with the yellow-bellied slider (*Trachemys scripta scripta*), which has a yellow vertical stripe behind each eye instead of red. It is also confused with the red-bellied cooter (*Pseudemys rubriventris*), which can be distinguished by a distinctive orange to reddish color on the underside of the shell and cusps on the upper **mandible**.

## Habitat

The red-eared slider is a hardy freshwater turtle that flourishes in many kinds of habitats and is frequently seen basking on rocks, logs, masses of vegetation, and banks. It prefers quiet waters such as ponds and wetlands, but will also inhabit slow-moving waterways, brackish waters, or even fairly polluted waters and can survive the cold of winter by hibernating in the silty, muddy bottoms of lakes and rivers.

## Spread

Despite a 1975 ban by the U.S. Food and Drug Administration on the sale of red-eared sliders less than four inches in **carapace** length, small hatchlings are still available for Internet or mail order. When they grow into large adults, pet owners often release them into the natural environment where they can establish reproducing populations.

## Distribution

The native range of the red-eared slider includes the Mississippi River Valley from Illinois south to Louisiana, west to eastern Texas, and east into western Alabama where they begin to naturally integrate with yellow-bellied sliders. With the help of humans, this turtle has been introduced into numerous countries around the world and can be found in most Mid-Atlantic states.



## Impacts

This aggressive omnivore feeds on fish, plants, insects, amphibians, and other aquatic organisms and their eggs, directly competing with many native aquatic and terrestrial turtles for food, basking areas, and nesting sites. Its ability to survive and reproduce in polluted waters makes it prone to contracting and spreading diseases. In the southeastern Coastal Plain of the United States, **hybridization** with the native yellow-bellied slider and the "genetic swamping" of the native gene pool is considered a serious conservation concern.



# African Clawed Frog

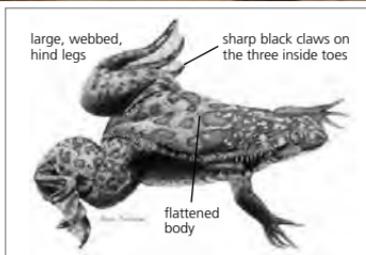
*Xenopus laevis*



## Species at a Glance

The African clawed frog is from a unique family of frogs called *Pipidae* that lack a tongue and visible ears. It was widely used as an experimental amphibian in laboratories and also became a

popular pet species, leading to releases and escapes from captivity that have allowed this highly adaptable species to form invasive populations around the world.



## Identification

This plump, medium-sized aquatic frog has a flattened body and a wedge-shaped head that is smaller than the body. Males are 5-6 cm (2.5 in) long and females are larger, reaching 10-12 cm (4 in). Instead of moveable eyelids, this species has a horny transparent covering that protects the small, upward turned eyes. The front limbs are small with unwebbed fingers and the hind legs are large and webbed. The three inside toes on the back feet have sharp black claws. The skin is smooth and slippery, except where the **lateral line** gives the appearance of “stitching”. It is multicolored on the back with blotches of olive-gray or brown and the underside is creamy white or yellowish. This frog has the ability to change its appearance to match its background; therefore, it can become dark, light, or mottled. A distinguishing characteristic is that males lack a vocal sac. Females also have a **cloacal** extension at the end of the abdomen.

## Similar Species

No frog in North America resembles this species.

## Habitat

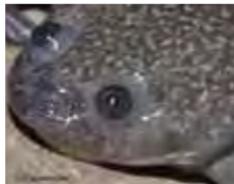
A water-dependent species, the African clawed frog occurs in a wide range of habitats, including heavily modified and degraded ecosystems. It prefers stagnant pools and quiet streams and tends to avoid large rivers and waterbodies with predatory fish. It can tolerate wide fluctuations in pH; however, metal ions are toxic to it. It leaves the water only when forced to migrate, crawling over long distances to other ponds. During dry conditions, this frog can burrow into the mud and lie dormant for up to a year.

## Spread

The African clawed frog was introduced as a laboratory test species to be used in pregnancy tests after it was discovered that females would begin laying eggs when injected with a pregnant woman's urine. It was in such high demand that large numbers were bred in captivity and a significant pet trade developed in the 1960s. It was intentionally released from laboratories around the world when new technologies for pregnancy diagnosis were developed in the late 1950s. Other modes of introduction include intentional releases of unwanted pets and escapes from aquariums, especially because of its long lifespan of up to 15 years.

## Distribution

Native to southern and western regions of Africa, the African clawed frog was shipped around the world in the 1940s and 1950s. In the Mid-Atlantic region, the frog is established in Virginia ponds, and has also been collected in North Carolina.



## Impacts

The African clawed frog has a voracious appetite and will eat anything it catches, including native invertebrates, frogs, fish, and birds, as well as its own tadpoles. It can out-compete native frogs and other aquatic species and can act as a vector for parasites and diseases such as chytrid fungus that can be transmitted to native frogs. It can also secrete a skin toxin that may be harmful to predators, including native fish.



# Field Guide References

---

**The following primary sources were used for multiple species in the field guide:**

1. Aquatic Invasive Species Management Plan Committee (AISMP). 2006. Commonwealth of Pennsylvania Invasive Species Council Aquatic Invasive Species Management Plan.
2. Center for Invasive Species and Ecosystem Health. <<http://www.invasive.org>>.
3. Fuller, P. et al. NAS-Nonindigenous Aquatic Species database. United States Geological Survey database. <<http://nas.er.usgs.gov/>>.
4. Great Lakes Aquatic Nonindigenous Species Information System. GLANSIS. NOAA. <<http://www.glerl.noaa.gov/res/Programs/glansis/glansis.html> >.
5. Huebner, C.D., Olson, C. and Smith, H.C. 2006. Invasive Plant Field and Reference Guide: An ecological perspective of plant invaders of forests and woodlands. USDA Forest Service.
6. Indiana Department of Natural Resources. Aquatic Invasive Species factsheets. <<http://www.in.gov/dnr/3123.htm>>.
7. Invasive Species Specialist Group (ISSG) of the IUCN Species Survival Commission. Global Invasive Species Database. <<http://www.issg.org/database/welcome/>>.
8. Lake Champlain Basin Program and the Aquatic Nuisance Species Task Force. Lake Champlain Basin Aquatic Invasive Species Guide.
9. Lui, K., Butler, M., Allen, M., de Silva, J., and Brownson, B. 2008. Field Guide to Aquatic Invasive Species: Identification, collection, and reporting of aquatic invasive species in Ontario waters. Ontario Ministry of Natural Resources.
10. Maine Center for Invasive Aquatic Plants. 2007. Maine Field Guide to Invasive Aquatic Plants and their Common Native Look Alikes. Maine Volunteer Lake Monitoring Program.
11. Plant Conservation Alliance's Alien Plant Working Group. Least Wanted: Alien Plant Invaders of Natural Areas. <<http://www.nps.gov/plants/alien/fact.htm>>.
12. United States Department Agriculture Plants Database. <<http://plants.usda.gov/java/>>.
13. University of Florida Center for Aquatic and Invasive Plants. <<http://plants.ifas.ufl.edu/>>.
14. Wisconsin Department of Natural Resources. Aquatic Invasive Species Factsheets. <<http://dnr.wi.gov/topic/Invasives/>>.

Below is a list of species with additional sources other than those listed prior:

**INVASIVE AQUATIC PLANTS:**

Brittle Naiad

1. Invasive Plant Atlas of New England. Brittle water-nymph page. <[http://www.eddmaps.org/pane/panespecies/aquatics/Najas\\_minor.htm](http://www.eddmaps.org/pane/panespecies/aquatics/Najas_minor.htm)>.
2. Richardson, R., Lassiter, B., Wilkerson, G., and Hoyle, S. 2008. Brittle Naiad. North Carolina State University. <<http://www.weedscience.ncsu.edu/aquaticweeds/factsheets/BrittleNaiad.pdf>>.

Common Salvinia

1. Texas A & M Agrilife Extension. Common Salvinia page. <<http://aquaplant.tamu.edu/plant-identification/alphabetical-index/common-salvinia/>>.

Creeping water-primrose

1. Booy, O., Wade, M. and White, V. Creeping Water-primrose. NNSB GB non-native species secretariat. <[www.nonativespecies.org](http://www.nonativespecies.org)>.
2. King County, Washington. 2016. Floating primrose-willow. Species Page. <<http://www.kingcounty.gov/environment/animalsAndPlants/noxious-weeds/weed-identification/floating-primrose-willow.aspx>>.
3. Washington State Noxious Weed Control Boards. 2010. Floating primrose-willow (*Ludwigia peploides*). Species page. <<http://www.nwcb.wa.gov/detail.asp?weed=88>>.
4. Wildscreen Arkive. Creeping water-primrose (*Ludwigia peploides*). Fact File. <<http://www.arkive.org/creeping-water-primrose/ludwigia-peploides/>>.

Eurasian watermilfoil

1. Jensen, D. 2010. Eurasian watermilfoil (*Myriophyllum spicatum*). University of Minnesota Sea Grant. <<http://www.seagrants.umn.edu/ais/watermilfoil>>.

European frogbit

1. New York Sea Grant. 2007. European frog-bit (*Hydrocharis morsus-ranae*)-Floating Invader of Great Lakes Basin Waters. NYSG Invasive Species Factsheet Series: 07-1. <<http://www.seagrants.sunysb.edu/ais/pdfs/Frog-bitFactsheet.pdf>>.

European water clover

1. Hilty, J. 2015. Illinois wildflowers. European Water Clover. <[http://www.illinoiswildflowers.info/grasses/plants/water\\_clover.html](http://www.illinoiswildflowers.info/grasses/plants/water_clover.html)>.
2. Midwest Invasive Plant Network. New Invasive Plants of the Midwest Fact Sheet: European water clover (*Marsilea quadrifolia*). <<http://bugwoodcloud.org/mura/mipn/assets/File/EDRRpdfs/Europeanwaterclover-Marsileaquadrifolia.pdf>>.

European water-starwort

1. Department of Ecology, State of Washington. Submersed Plants: *Callitriche stagnalis* Scop., pond water-starwort. <<http://www.ecy.wa.gov/programs/wq/plants/plantid2/descriptions/calsta.html>>.
2. Rawlins, K.A. 2014. *Callitriche stagnalis*. NJ. Center for Invasive Species and Ecosystem Health at the University of Georgia. <[http://wiki.bugwood.org/Callitriche\\_stagnalis/NJ](http://wiki.bugwood.org/Callitriche_stagnalis/NJ)>.

#### Fanwort

1. Maine Natural Areas Program and University of Maine Cooperative Extension. 2007. Maine Invasive Plants: Fanwort, *Cabomba*. University of Maine Bulletin #2522. <<http://extension.umaine.edu/publications/2522e/>>.
2. Robinson, M. 2002. Fanwort: An invasive aquatic plant. Massachusetts DCR factsheet. <<http://www.mass.gov/dcr/watersupply/lakepond/factsheet/Fanwort.pdf>>.
3. State of Washington Department of Ecology. Non-native invasive freshwater plants: *Cabomba caroliniana* (Fanwort)-Technical information. <<http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua006.html>>.

#### Giant Salvinia

1. National Park Service. 2010. Giant Salvinia page. Alien Plant Invaders of Natural Areas. <<https://www.nps.gov/plants/alien/pubs/midatlantic/samo.htm>>.

#### Hydrilla

1. Langeland, K.A. 1996. *Hydrilla verticillata* (L.F.) Royle (*Hydrocharitaceae*), "The perfect aquatic weed." *Castanea* 61:293-304.
2. Posey, MH; Wigand, C; Stevenson, JC. 1993. Effects of an introduced aquatic plant, *Hydrilla verticillata*, on benthic communities in the upper Chesapeake Bay. *Estuarine, Coastal and Shelf Science* 37:539-555.
3. Rybicki, Nancy B., et al. 2007. Long-term changes in Abundance and Diversity of Macrophyte and Waterfowl Populations in an Estuary with Exotic Macrophytes and Improving Water Quality. *The American Society of Limnology and Oceanography* 52(3): 1195-1207.
4. The University of Georgia, USDA Forest Service, & USDA APHIS PPO. 2003. Invasive Plants of the Eastern United States: Hydrilla. <<http://www.invasive.org/eastern/biocontrol/7Hydrilla.html>> (Accessed October 2007).

#### Mudmat

1. Goodman, T. 1998. Have you seen this plant? It's mud mat. USDA APHIS pest alert. <[http://www.aphis.usda.gov/publications/plant\\_health/content/printable\\_version/mudmatpa.ppd](http://www.aphis.usda.gov/publications/plant_health/content/printable_version/mudmatpa.ppd)>.
2. Jacono, C.C. 2007. *Glossostigma cleistanthum* (mud mat). USGS Southeast Ecological Science Center. <[http://fl.biology.usgs.gov/Nonindigenous\\_Species/Glossostigma/glossostigma.html](http://fl.biology.usgs.gov/Nonindigenous_Species/Glossostigma/glossostigma.html)>.

#### Parrotfeather

1. State of Washington Department of Ecology. Non-native invasive freshwater plants: Parrotfeather (*Myriophyllum aquaticum*)-Technical information. <<http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua003.html>>.
2. Virginia Department of Conservation & Recreation. 1999. Invasive alien plant species of Virginia: Parrot's feather (*Myriophyllum aquaticum*). <[http://www.dcr.virginia.gov/natural\\_heritage/documents/fsmyaq.pdf](http://www.dcr.virginia.gov/natural_heritage/documents/fsmyaq.pdf)>.

#### Pink lotus

1. Boggs, J. 2015. Sacred Lotus May Not Be So Sacred. Ohio State University. Hort Shorts. <<http://bygl.osu.edu/content/sacred-lotus-may-not-be-so-sacred-0>>.
2. Hilty, J. 2015. Wetland Wildflowers of Illinois. Sacred Lotus. <[http://www.illinoiswildflowers.info/wetland/plants/sacred\\_lotus.htm](http://www.illinoiswildflowers.info/wetland/plants/sacred_lotus.htm)>.

#### Waterwheel

1. Brookman, S. 2015. *Aldrovanda vesiculosa*. Bugwood.org Wiki. <[http://wiki.bugwood.org/Aldrovanda\\_vesiculosa/NJ](http://wiki.bugwood.org/Aldrovanda_vesiculosa/NJ)>.

## Water chestnut

1. Van Driesche, R., et al. 2002. Biological Control of Invasive Plants in the Eastern United States. USDA Forest Service Publication FHTET-2002-04: 413. <<http://invasiveplants.net/InvasivePlants/WaterChestnut/WaterChestnut.asp>>.

## Yellow floating heart

1. Block, T. A. and Rhoads, A.F. 2011. Aquatic Plants of Pennsylvania, University of Pennsylvania Press, Philadelphia, Pennsylvania, p. 145.
2. Indiana Department of Natural Resources. 2005. Aquatic Invasive Species: Yellow floating heart. <[http://www.in.gov/dnr/files/YELLOW\\_FLOATING\\_HEART.pdf](http://www.in.gov/dnr/files/YELLOW_FLOATING_HEART.pdf)>.
3. Washington State Noxious Weed Control Board. 2010. Yellow Floating Heart species page. <<http://www.nwcb.wa.gov/detail.asp?weed=98>>.

**INVASIVE WETLAND PLANTS:**

## Alligatorweed

1. Texas A&M Agrilife Extension. 2016. Alligator Weed (*Alternanthera philoxeroides*) website. <<http://aquaplant.tamu.edu/plant-identification/alphabetical-index/alligator-weed/>>.
2. Virginia Department of Conservation and Recreation (DCR). Invasive Alien Plant Species of Virginia: Alligatorweed. <[http://www.dcr.virginia.gov/natural\\_heritage/documents/fsalph.pdf](http://www.dcr.virginia.gov/natural_heritage/documents/fsalph.pdf)>.

## Asian spiderwort

1. Clemson Cooperative Extension. Asian Spiderwort. <[http://www.clemson.edu/extension/horticulture/nursery/remediation\\_technology/constructed\\_wetlands/plant\\_material/asian\\_spiderwort.html](http://www.clemson.edu/extension/horticulture/nursery/remediation_technology/constructed_wetlands/plant_material/asian_spiderwort.html)>.
2. Virginia Department of Conservation and Recreation (DCR). Invasive Alien Plant Species of Virginia: Aneilema (*Murdannia keisak* (Hasskarl) Hand.-Mazz). Fact sheet. <[http://www.dcr.virginia.gov/natural\\_heritage/documents/fsmuke.pdf](http://www.dcr.virginia.gov/natural_heritage/documents/fsmuke.pdf)>.

## Asiatic Sand Sedge

1. The University of Georgia. Asiatic Sand Sedge Profile. Invasive Plant Atlas of New England. <[http://www.eddmaps.org/ipane/ipanespecies/herbs/carex\\_kobomugi.htm](http://www.eddmaps.org/ipane/ipanespecies/herbs/carex_kobomugi.htm)>.
2. Virginia Department of Conservation and Recreation (DCR). Invasive Alien Plant Species of Virginia: Asiatic Sand Sedge (*Carex kobomugi*) Ohwi. Factsheet. <[http://www.dcr.virginia.gov/natural\\_heritage/documents/fscako.pdf](http://www.dcr.virginia.gov/natural_heritage/documents/fscako.pdf)>.

## Beach vitex

1. Maddox, V., Westbrooks, R., Byrd, J.D. Jr., Brabson, B. Beach Vitex Website. Invasive Plant Atlas of the Mid-South. <<https://www.gri.msstate.edu/ipams/species.php?CName=Beach%20vitex>>.

## Common Reed (Phragmites)

1. Saltonstall, K. 2002. Cryptic invasion by a non-native genotype of the common reed, *Phragmites australis*, into North America. Proceedings of the National Academy of Sciences of the United States of America. 99 (4): 2445-2449.
2. University of Rhode Island CELS Outreach Center. Common Reed (*Phragmites australis*) Control Fact Sheet. <[http://www.uri.edu/cels/ceoc/documents/common\\_reed.pdf](http://www.uri.edu/cels/ceoc/documents/common_reed.pdf)>.

#### Flowering rush

1. Jensen, D. 2009. Flowering Rush (*Butomus umbellatus*). University of Minnesota Sea Grant. <<http://www.seagrants.umn.edu/ais/floweringrush>>.
2. Mid-west Invasive Plant Network. New Invasive Plants of the Midwest Fact Sheet: Flowering Rush. <<http://www.mipn.org/Midwest%20Invasives%20Fact%20Sheet%20Sheets/PDF/floweringrush.pdf>>.

#### Garlic mustard

1. Rhoads, A.F. and Block, T.A. 2011. Garlic Mustard (*Alliaria petiolata*) Invasive Species Fact Sheet. Morris Arboretum of the University of Pennsylvania. <<http://paflora.org/original/pdf/INV-Fact%20Sheets/Alliaria%20petiolata.pdf>>.
2. Forest Invasive Plants Resource Center. Garlic Mustard (*Alliaria petiolata*). Fact Sheet. <<http://na.fs.fed.us/spfo/invasiveplants/factsheets/pdf/garlic-mustard.pdf>>.

#### Giant hogweed

1. O'Neill C.R. 2009. Giant Hogweed (*Heracleum mantegazzianum*) - Poisonous Invader of the Northeast. New York Sea Grant Invasive Species Factsheet Series: 07-1. <[http://www.dec.ny.gov/docs/lands\\_forests\\_pdf/ghfactnyseagrant.pdf](http://www.dec.ny.gov/docs/lands_forests_pdf/ghfactnyseagrant.pdf)>.

#### Giant knotweed

1. USDA Forest Service, Forest Health Staff. 2006. Giant Knotweed. Weed of the week. <[http://na.fs.fed.us/fhp/invasive\\_plants/weeds/giant-knotweed.pdf](http://na.fs.fed.us/fhp/invasive_plants/weeds/giant-knotweed.pdf)>.

#### Japanese hops

1. Invasive Plant Species Assessment Working Group. 2007. Japanese Hops *Humulus japonicus*. Invasive plant species fact sheet. <[http://www.in.gov/dnr/files/Japanese\\_Hops.pdf](http://www.in.gov/dnr/files/Japanese_Hops.pdf)>.
2. United States Department of Agriculture (USDA) Forest Service, Forest Health Staff. 2005. Japanese Hop. Weed of the Week. <[http://www.na.fs.fed.us/fhp/invasive\\_plants/weeds/japanese-hop.pdf](http://www.na.fs.fed.us/fhp/invasive_plants/weeds/japanese-hop.pdf)>.
3. Virginia Tech. Japanese Hops: *Humulus japonicus*. Virginia Tech Weed Identification Guide. <[http://www.ppws.vt.edu/scott/weed\\_id/humja.htm](http://www.ppws.vt.edu/scott/weed_id/humja.htm)>.

#### Japanese knotweed

1. Invasive Plant Species Assessment Working Group. 2006. Japanese Knotweed *Polygonum cuspidatum* (*Fallopia japonica*). Invasive Plant Species Fact Sheet. <[http://www.in.gov/dnr/files/Japanese\\_Knotweed.pdf](http://www.in.gov/dnr/files/Japanese_Knotweed.pdf)>.
2. Virginia Tech. Japanese Bamboo or Japanese Knotweed: *Polygonum cuspidatum*. Virginia Tech Weed Identification Guide. <[http://www.ppws.vt.edu/scott/weed\\_id/polcu.htm](http://www.ppws.vt.edu/scott/weed_id/polcu.htm)>.

#### Japanese stiltgrass

1. Midwest Invasive Plant Network. Japanese Stiltgrass *Microstegium vimineum*. New Invasive Plants of the Midwest Fact Sheet. <<http://www.mipn.org/Midwest%20Invasives%20Fact%20Sheet%20Sheets/PDF/Japstilt.pdf>>.
2. Swearingen, J.M. 2004. Japanese stiltgrass, Nepalese browntop *Microstegium vimineum* (Trin.) Camus. DCNR Invasive Exotic Plant Tutorial for Natural Lands Managers. <[http://www.dcnr.state.pa.us/forestry/invasivetutorial/Japanese\\_stiltgrass.htm](http://www.dcnr.state.pa.us/forestry/invasivetutorial/Japanese_stiltgrass.htm)>.

#### Lesser celandine

1. Maine Natural Areas programs and resources. 2004. Maine Invasive Plants: Lesser Celandine. Bulletin #2534. <<http://extension.umaine.edu/publications/2534e/>>.

#### Moneywort

1. Pennsylvania Department of Conservation and Natural Resources. Invasive Plants in Pennsylvania: Moneywort (*Lysimachia nummularia* L.) factsheet. <[http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr\\_010246.pdf](http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_010246.pdf)>.
2. U.S. Forest Service, Forest Health Staff. 2005. Moneywort. Weed of the Week. <[http://www.na.fs.fed.us/fhp/invasive\\_plants/weeds/monewart.pdf](http://www.na.fs.fed.us/fhp/invasive_plants/weeds/monewart.pdf)>.
3. U.S. Forest Service. *Lysimachia nummularia*. Fire Effects Information System website <<http://www.fs.fed.us/database/feis/plants/forb/lysunum/all.html>>.

#### Narrowleaf and hybrid cattail

1. Invasive Species Council of Manitoba. Narrow-leaved and Hybrid cattail. <<http://www.invasivespeciesmanitoba.com/site/index.php?page=narrow-leaved-and-hybrid-cattail>>.

#### Poison Hemlock

1. Eubank, E. and Rathfon, R. 2012. Invasive Plant Series: Poison Hemlock. Southern Indiana Cooperative Weed Management Area. Purdue Extension. <<https://www.extension.purdue.edu/extmedia/fnr/fnr-437-w.pdf>>.
2. King County Noxious Weed Control Management Program. 2011. Poison Hemlock Weed Alert Fact Sheet. <[http://your.kingcounty.gov/dnrp/library/water-and-land/weeds/Brochures/Poison-Hemlock\\_factsheet.pdf](http://your.kingcounty.gov/dnrp/library/water-and-land/weeds/Brochures/Poison-Hemlock_factsheet.pdf)>.
3. Pokorny, M. and Sheley, R. 2012. Poison Hemlock (*Conium maculatum*). Montana State University Extension. <<http://store.msuxextension.org/publications/AgandNaturalResources/MT200013AG.pdf>>.

#### Policeman's helmet

1. King County. 2016. King County Noxious Weed Alert: Policeman's Helmet (*Impatiens glandulifera*) <[http://your.kingcounty.gov/dnrp/library/water-and-land/weeds/Brochures/Policeman's\\_Helmet\\_factsheet.pdf](http://your.kingcounty.gov/dnrp/library/water-and-land/weeds/Brochures/Policeman's_Helmet_factsheet.pdf)>.

#### Purple loosestrife

1. State of Washington Department of Ecology. Non-native invasive freshwater plants: Purple Loosestrife (*Lythrum salicaria*), Technical information. <<http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua009.html>>.
2. United States Department of Agriculture (USDA) Forest Service, Forest Health Staff. 2005. Purple Loosestrife *Lythrum salicaria*. Weed of the Week. <[http://na.fs.fed.us/FHP/INVASIVE\\_PLANTS/weeds/purple-loosestrife.pdf](http://na.fs.fed.us/FHP/INVASIVE_PLANTS/weeds/purple-loosestrife.pdf)>.

#### Reed canary grass

1. Indiana Department of Natural Resources. 2012. Reed Canary Grass. Aquatic Invasive Species. <[http://www.in.gov/dnr/files/REED\\_CANARY\\_GRASS.pdf](http://www.in.gov/dnr/files/REED_CANARY_GRASS.pdf)>.
2. State of Washington Department of Ecology. Non-native invasive freshwater plants: Reed Canarygrass (*Phalaris arundinacea*) Technical Information. <<http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua011.html>>.

#### Wavyleaf basketgrass

1. Westbrook, R. and Imlay, M. 2009. Wavyleaf Basketgrass-A new Invader of Deciduous Forests in Maryland and Virginia. Fact Sheet. <<http://www.se-epcc.org/southcarolina/wlbg.pdf>>.
2. Pennsylvania Department of Conservation and Natural Resources. Invasive Plants in Pennsylvania: Wavyleaf Basketgrass Fact Sheet. <[http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr\\_010307.pdf](http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_010307.pdf)>.

## **INVASIVE INVERTEBRATES:**

### Asian clam

1. Naumann, R. 1999. *Corbicular fluminea* (on-line). Animal Diversity Web. <[http://animaldiversity.ummz.umich.edu/site/accounts/information/Corbicula\\_fluminea.html](http://animaldiversity.ummz.umich.edu/site/accounts/information/Corbicula_fluminea.html)>.

### Australian spotted jellyfish

1. Masterson, J. 2007. Species Inventory Homepage: *Phyllorhiza punctata* (Australian Spotted Jellyfish). Smithsonian Marine Station and Fort Pierce. <[http://www.sms.si.edu/irlspec/Phyllorhiza\\_punctata.htm](http://www.sms.si.edu/irlspec/Phyllorhiza_punctata.htm)>

### Chinese mitten crab

1. Chinese mitten crab working group. 2003. National Management Plan for the Genus *Eriocheir* (Mitten crabs).
2. Crosier, D.M., and Malloy, D.P. 2003. Chinese Mitten Crab-*Eriocheir sinensis*. Aquatic Nuisance Species Research Program. <[http://el.ercd.usace.army.mil/ansrp/species\\_profiles.htm](http://el.ercd.usace.army.mil/ansrp/species_profiles.htm)>.
3. Metzler, J.L. Chinese mitten crab (*Eriocheir sinensis*). Illinois-Indiana Sea Grant. <[http://www.iisgcp.org/exoticsp/Chinese\\_Mitten\\_Crab.htm](http://www.iisgcp.org/exoticsp/Chinese_Mitten_Crab.htm)>.
4. New York State Department of Environmental Conservation. Chinese mitten crab in the Hudson River Estuary. <<http://www.dec.ny.gov/animals/35888.html>>.

### Chinese pond mussel

1. New Jersey Invasive Species Strike Team. Chinese Pond Mussel (*Sinanodonta woodiana*). <[http://www.njisst.org/fact-sheets/mollusks/Sinanodonta%20woodiana\\_2011.pdf](http://www.njisst.org/fact-sheets/mollusks/Sinanodonta%20woodiana_2011.pdf)>.
2. U.S. Fish and Wildlife Service. 2015. Chinese Pondmussel (*Sinanodonta woodiana*). Ecological Risk Screening. <<https://www.fws.gov/fisheries/ans/erss/highrisk/Sinanodonta-woodiana-ERSS-revision-July2015.pdf>>.

### Faucet snail

1. Kipp, R.M., A.J. Benson, J. Larson, and A. Fusaro. 2016. *Bithynia tentaculata*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. <<http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=987>>.
2. Minnesota Department of Natural Resources. 2016. Faucet Snail (*Bithynia tentaculata*) page. <[http://www.dnr.state.mn.us/invasives/aquaticanimals/faucet\\_snail/index.html](http://www.dnr.state.mn.us/invasives/aquaticanimals/faucet_snail/index.html)>.
3. Minnesota Sea Grant. 2016. Faucet Snails (*Bithynia tentaculata*) species profile. <<http://www.seagrants.umn.edu/ais/faucetsnail>>.

### Golden mussel

1. Crosier, D.M. and Molloy, D. P. Golden Mussel-*Limnoperna fortunei*. U.S. Army Corps of Engineers Fact Sheet. <[http://el.ercd.usace.army.mil/ansrp/limnoperna\\_fortunei.pdf](http://el.ercd.usace.army.mil/ansrp/limnoperna_fortunei.pdf)>.
2. Miles, I. 2015. Species Spotlight: Golden Mussel. Illinois Indiana Sea Grant News Room. <<http://www.iiseagrant.org/newsroom/news/species-spotlight-golden-mussel/>>.
3. University of Wisconsin Sea Grant Institute. 2013. Golden mussel (*Limnoperna fortunei*). Fact sheet. <<http://seagrant.wisc.edu/Home/Topics/InvasiveSpecies/Details.aspx?PostID=1941>>.

### Green crab

1. Washington Department of Fish & Wildlife. *Carcinus maenas* (European Green crab). Fact sheet. <[http://wdfw.wa.gov/ais/carcinus\\_maenas/#impacts](http://wdfw.wa.gov/ais/carcinus_maenas/#impacts)>.

## Marbled crayfish

1. Martin, P, Dorn, N.J., Kwai, T, Van der Heiden, C., and Scholtz, G. 2010. The enigmatic Marmorokrebs (marbled crayfish) is the parthenogenetic form of *Procambarus fallax* (Hagen, 1870). *Contributions to Zoology* **79** (3): 107–118. <<http://dpc.uba.uva.nl/cgi/t/text/get-pdf?c=ctz;idno=7903a03>>.
2. United States Fish and Wildlife Service. 2015. Marmorokrebs (*Procambarus fallax f. virginalis*) Ecological Risk Screening Summary. <<http://www.fws.gov/fisheries/ans/erss/uncertainrisk/Procambarus-fallax-f-virginalis-ERSS-revision-June2015.pdf>>.
3. Zieritz, A. 2011. Marbled Crayfish, *Procambarus marmorokrebs*. GB non-native species secretariat <<http://www.nonnativespecies.org/factsheet/downloadFactsheet.cfm?speciesId=2837>>.

## New Zealand mudsnail

4. Crosier, D. and Malloy, D. 2005. New Zealand Mudsnail (*Potamopyrgus antipodarum*). Aquatic Nuisance Species Taskforce. <<http://www.anstaskforce.gov/spoc/nzms.php>>.
5. Minnesota Department of Natural Resources. 2012. New Zealand Mudsnail (*Potamopyrgus antipodarum*). <[http://www.dnr.state.mn.us/invasives/aquaticanimals/nz\\_mudsnail/index.html](http://www.dnr.state.mn.us/invasives/aquaticanimals/nz_mudsnail/index.html)>.

## Quagga mussel

1. Michigan Sea Grant. Quagga mussels. Factsheet. <[http://www.miseagrant.umich.edu/downloads/ais/fs\\_quagga\\_mussel.pdf](http://www.miseagrant.umich.edu/downloads/ais/fs_quagga_mussel.pdf)>.

## Red swamp crayfish

1. Lieb, D., Bouchard, R. W., and Carline, R.F. 2011. Crayfish Fauna of Southeastern Pennsylvania: Distributions, Ecology, and Change over the Last Century. *Journal of Crustacean Biology*. 31 (1): 166-178. <<http://www.bioone.org/doi/abs/10.1651/10-3287.1>>.
2. Minnesota Sea Grant. Red Swamp Crayfish (*Procambarus clarkii*). Species page. <<http://www.seagrant.umn.edu/ais/redswampcrayfish>>.

## Rusty crayfish

1. Gunderson, J. 1998. Rusty crayfish- a nasty invader. Minnesota Sea Grant. <[http://www.seagrant.umn.edu/ais/rustycrayfish\\_invader](http://www.seagrant.umn.edu/ais/rustycrayfish_invader)>.
2. Wilson, K.A. 2002. Impacts of the invasive rusty crayfish (*Orconectes rusticus*) in northern Wisconsin lakes. Dissertation Abstracts International Part B: Science and Engineering. 63 (4): 1662.

## Spiny waterflea

1. O'Neill, C.R. Jr. 2008. Spiny waterflea. New York Invasive Species.

## Veined rapa whelk

1. Chesapeake Bay Program. Veined Rapa Whelk, *Rapana venosa*. Field guide <[http://www.chesapeakebay.net/fieldguide/critter/veined\\_rapa\\_whelk](http://www.chesapeakebay.net/fieldguide/critter/veined_rapa_whelk)>.

## Virile crayfish

1. Missouri Department of Conservation. Northern Crayfish (Virile Crayfish) *Orconectes virilis*. <<http://nature.mdc.mo.gov/discover-nature/field-guide/northern-crayfish-virile-crayfis>>.

## Zebra mussel

2. Jensen, D. 2010. Zebra mussel (*Dreissena polymorpha*). <<http://www.seagrant.umn.edu/ais/zebramussel>>.

## **INVASIVE MAMMALS AND BIRDS:**

### Feral hog

1. New York Sea Grant and Cornell University. 2014. Feral Swine (*Sus scrofa*) Factsheet. <[http://www.nyis.info/user\\_uploads/files/Feral%20Swine%20072314%20-%20Final.pdf](http://www.nyis.info/user_uploads/files/Feral%20Swine%20072314%20-%20Final.pdf)>.
2. United States Department of Agriculture Animal and Plant Health Inspection Service. Feral Swine—Managing and Invasive Species. Website. <<https://www.aphis.usda.gov/aphis/resources/pests-diseases/feral-swine>>.

### Mute Swan

1. Minnesota Department of Natural Resources. Mute Swan Page. <<http://www.dnr.state.mn.us/invasives/terrestrialanimals/muteswan/index.html>>.
2. Michigan Department of Natural Resources. 2016. Mute Swans—Invading Michigan's Waters. <[http://www.michigan.gov/dnr/0,4570,7-153-10370\\_12145\\_59132\\_59333-263418--,00.html](http://www.michigan.gov/dnr/0,4570,7-153-10370_12145_59132_59333-263418--,00.html)>.
3. New York State Department of Environmental Conservation Division of Fish, Wildlife, and Marine Resources. 2015. Management Plan for Mute Swans of New York. <[http://www.dec.ny.gov/docs/wildlife\\_pdf/muteswanmgmtpln2015.pdf](http://www.dec.ny.gov/docs/wildlife_pdf/muteswanmgmtpln2015.pdf)>.

### Nutria

1. Burk, P.W., Witmer, G.W., Jojola, S.M., and Nolte, D.L. 2008. Improving Nutria Trapping Success. Proceedings of the 23rds Vertebrate Pest Conference. San Diego, California. <<http://naldc.nal.usda.gov/download/23404/PDF>>.
2. United States Department of Agriculture: Wildlife Services. 2010. Nutria, an Invasive Rodent. Factsheet. <[http://www.aphis.usda.gov/publications/wildlife\\_damage/content/printable\\_version/fs\\_nutria10.pdf](http://www.aphis.usda.gov/publications/wildlife_damage/content/printable_version/fs_nutria10.pdf)>.
3. United States Geological Survey. 2000. Nutria, Eating Louisiana's Coast. Factsheet. <<http://www.nwrc.usgs.gov/factshts/020-00.pdf>>.

### Resident Canada goose

1. The Cornell Lab of Ornithology. 2015. Canada Goose. All About Birds. <[https://www.allaboutbirds.org/guide/Canada\\_Goose/d#similar](https://www.allaboutbirds.org/guide/Canada_Goose/d#similar)>.

## **INVASIVE FISH:**

### Asian swamp eel

1. MIT Sea Grant College Program. Asian Swamp Eel Fact Sheet. MIT Coastal Resources. <<http://massbay.mit.edu/seafood/asianswampeel.pdf>>.
2. Shafland, P.L., Gestring, K.B. & Stanford, M.S. 2009. An Assessment of Asian Swamp Eel (*Monopterus albus*) in Florida. Reviews in Fisheries Science. 18 (1): 25-39.

### Blue catfish

1. Chesapeake Bay Program. Blue Catfish species page. <[http://www.chesapeakebay.net/fieldguide/critter/blue\\_catfish](http://www.chesapeakebay.net/fieldguide/critter/blue_catfish)>.
2. Chesapeake Bay Program. Invasive Catfish in the Chesapeake Bay. Factsheet. <[http://dnr2.maryland.gov/fisheries/Documents/Invasive\\_Catfish\\_%20Fact\\_Sheet.pdf](http://dnr2.maryland.gov/fisheries/Documents/Invasive_Catfish_%20Fact_Sheet.pdf)>.
3. Virginia Department of Game and Inland Fisheries. Blue Catfish species page. <<http://www.dgif.virginia.gov/wildlife/fish/details.asp?fish=010390>>.

### Blue tilapia and redbelly tilapia

1. MIT Sea Grant Coastal Resources. 2006. Tilapia Fact Sheet. <<https://massbay.mit.edu/seafood/tilapia.pdf>>.

#### Common carp

1. Minnesota Department of Natural Resources. Common carp, German carp, European carp (*Cyprinus carpio*). <<http://www.dnr.state.mn.us/invasives/aquaticanimals/commoncarp/index.html>>.

#### Goldfish

1. Luna, S.M. 2012. *Carassius auratus auratus*: Goldfish. Fishbase. World Wide Web Electronic Publication.
2. New World Encyclopedia contributors. 2008. Goldfish. New World Encyclopedia. <<http://www.newworldencyclopedia.org/p/index.php?title=Goldfish&oldid=679940>>.

#### Grass carp

1. Food and Agriculture Organization of the United Nations. Cultured Aquatic Species Information Programme. <[http://www.fao.org/fishery/culturedspecies/Ctenopharyngodon\\_idella/en](http://www.fao.org/fishery/culturedspecies/Ctenopharyngodon_idella/en)>.
2. Texas Parks and Wildlife. Grass carp (*Ctenopharyngodon idella*). <<http://www.tpwd.state.tx.us/huntwild/wild/species/gcarp/>>.
3. Tu, M. 2003. Invasive Species Notes: Triploid Grass Carp/White Amur (*Ctenopharyngodon idella* Val.). The Nature Conservancy's Wildland Invasive Species Team.

#### Lionfish

1. Gulf and Caribbean Fisheries Institute. 2008-2010. Lionfish Papers and Presentations from the Gulf and Caribbean Fisheries Institute. <<http://www.gcfi.org/Lionfish/LionfishPapersPresentations.pdf>>.
2. NOAA Education. 2016. Invasive Biology Fact Sheet. <<http://oceanservice.noaa.gov/education/stories/lionfish/factsheet.html>>.
3. NOAA Habitat Conservation. Lionfish fact sheet. <[http://www.habitat.noaa.gov/pdf/best\\_management\\_practices/fact\\_sheets/Lionfish%20Factsheet.pdf](http://www.habitat.noaa.gov/pdf/best_management_practices/fact_sheets/Lionfish%20Factsheet.pdf)>.

#### Northern snakehead and blotched snakehead

1. Courtenay, W. Jr., and Williams, J. D. Snakeheads (Pisces, *Channidae*) -A Biological Synopsis and Risk Assessment. US Geological Survey Circular 1251. <<http://nas.er.usgs.gov/taxgroup/fish/docs/SnakeheadRiskAssessment.pdf>>.
2. Orell, T.M. and Lee, W. 2005. The northern snakehead (*Channa argus*) (*Anabantomorpha Channidae*), a non-indigenous fish species in the Potomac River, USA. Proceedings of the Biological Society of Washington. 188(2): 407.
3. United States Fish and Wildlife Service. 2002. Invasive Species Program, Snakeheads-The Newest Aquatic Invader. <<http://www.dnr.state.md.us/fisheries/snakeheadfactsheetedited.pdf>>.

#### Oriental weatherfish

1. Frable, B. 2008. Invasive Species Profile: Oriental Weatherfish, *Misgurnus anguillicaudatus*. FISH 423. University of Washington. <[http://depts.washington.edu/oldenlab/wordpress/wp-content/uploads/2013/03/Misgurnus-anguillicaudatus\\_Frable.pdf](http://depts.washington.edu/oldenlab/wordpress/wp-content/uploads/2013/03/Misgurnus-anguillicaudatus_Frable.pdf)>.
2. Maryland Department of Natural Resources. Oriental Weatherfish Fact Sheet. <<http://dnr2.maryland.gov/Invasives/Documents/OrientalWeatherfishfactsheet.pdf>>.
3. Oregon Department of Fish and Wildlife. Invasive Species Fact Sheet. <[http://www.dfw.state.or.us/conservationstrategy/invasive\\_species/docs/oriental\\_weatherfish\\_fact\\_sheet.pdf](http://www.dfw.state.or.us/conservationstrategy/invasive_species/docs/oriental_weatherfish_fact_sheet.pdf)>.

#### Red shiner

1. Burkhead, N.M. and Hoge, D.H. 2002. The Case of the Red Shiner: What happens when a fish goes bad? Florida Integrated Science Center, Gainesville Florida.
2. Gido, K.B., Schaefer, J.F., Work, K.F., Marsh-Matthews, E. and Matthews, W.J. 1999. Effects of red shiner (*Cyprinella lutrensis*) on red river pupfish (*Cyprinodon rubrofluvialis*). The Southwestern Naturalist. 44(3): 287-295.
3. Matthews, W. J. 1987. Geographic variation in *Cyprinella lutrensis* (Pisces: *Cyprinidae*) in the United States, with Notes on *Cyprinella lepida*. Copeia 1987. 3 (1987): 616-637.
4. Matthews, W.J., Marsh-Matthews, E., Gido, K.B., and Marsh, R. 2002. Reproduction by young-of-year red shiner (*Cyprinella lutrensis*) and its implications for invasion success. The Southwestern Naturalist. 47 (4): 605-610.

#### Round Goby

1. ANS taskforce public awareness campaign. Harmful aquatic hitchhikers: Round goby. Protect your waters. <[http://www.protectyourwaters.net/hitchhikers/fish\\_round\\_goby.php](http://www.protectyourwaters.net/hitchhikers/fish_round_goby.php)>.
2. Crosier, D. and Malloy, D. 2005. Round Goby (*Neogobius melanostromus*). Aquatic Nuisance Species Taskforce. <[http://www.anstaskforce.gov/spoc/round\\_goby.php](http://www.anstaskforce.gov/spoc/round_goby.php)>.
3. Lake Huron Centre for Coastal Conservation. Round Goby. <<http://lakehuron.ca/index.php?page=round-goby>>.

#### Tubenose Goby

1. Lotts, C.K. Tubenose goby (*Proterorhinus marmoratus*). Illinois-Indiana Sea Grant. <<http://www.iisgpc.org/exoticsp/tubenosegoby.htm>>.
2. Ohio Department of natural resources. Tubenose goby. <<http://www.dnr.state.oh.us/Default.aspx?tabid=22722>>.

#### **PATHOGENS:**

##### Chytrid fungus

1. National Park Service. Amphibian chytrid fungus. <<https://www.nps.gov/pinn/learn/nature/chytrid.htm>>.

##### Eel swimbladder nematode

1. Bush, J., Johnson, L.B. 2014. Invasives Database: Eel swimbladder nematode. Texas Invasives.org. <[http://www.texasinvasives.org/pathogen\\_database/detail.php?symbol=4](http://www.texasinvasives.org/pathogen_database/detail.php?symbol=4)>.

##### Largemouth bass virus

1. Virginia Department of Game and Inland Fisheries. 2016. Largemouth bass virus in Virginia. <<https://www.dgif.virginia.gov/wildlife/diseases/largemouth-bass-virus/>>.

##### Ranavirus

1. United States Geological Survey. Ranavirus. National Wildlife Health Center. <[http://www.nwhc.usgs.gov/disease\\_information/other\\_diseases/ranavirus.jsp](http://www.nwhc.usgs.gov/disease_information/other_diseases/ranavirus.jsp)>.

##### Spring viremia of carp

1. The Center for Food Security and Public Health and The Institute for International Cooperation in Animal Biologics. 2007. Spring Viremia of Carp. Iowa State University. <[http://www.cfsph.iastate.edu/Factsheets/pdfs/spring\\_viremia\\_of\\_carp.pdf](http://www.cfsph.iastate.edu/Factsheets/pdfs/spring_viremia_of_carp.pdf)>.

##### Viral Hemorrhagic Septicemia (VHS)

1. The Center for Food Security and Public Health and The Institute for International Cooperation in Animal Biologics. 2007. Viral Hemorrhagic Septicemia. Iowa State University. <[http://www.cfsph.iastate.edu/Factsheets/pdfs/viral\\_hemorrhagic\\_septicemia.pdf](http://www.cfsph.iastate.edu/Factsheets/pdfs/viral_hemorrhagic_septicemia.pdf)>
2. Whelan, G.E. 2007. Viral Hemorrhagic Septicemia (VHS) Briefing Paper. Michigan DNR.

## Whirling disease

1. Kaeser, A. J., Rasmussen, C. and Sharpe, W.E. 2006. An Examination of Environmental Factors Associated with *Myxobolus cerebralis* Infection of Wild Trout in Pennsylvania. Journal of Aquatic Animal Health. 18: 90-100.
2. Protect your waters. Harmful Aquatic Hitchhikers: Whirling Disease. ANS Task Force page. <[http://www.protectyourwaters.net/hitchhikers/others\\_whirling\\_disease.php](http://www.protectyourwaters.net/hitchhikers/others_whirling_disease.php)>.
3. Whirling Disease Initiative. 2006. Whirling Disease fact Sheet. Montana Water Center. <<http://whirlingdisease.montana.edu/pdfs/WHIRLING%20DISEASE%20FACT%20SHEET.pdf>>.
4. Faisal, M. and Garling, D. What is Whirling Disease? North Central Regional Aquaculture Center and Michigan State University. <<http://www.ncrac.org/NR/rdonlyres/3CBCECF1E-2AE0-4661-9C08-29A0A15DE403/26267/Whirling2.pdf>>.
5. Gilbert, M.A. and Granath Jr., W.O. 2003. Whirling Disease of Salmonid Fish: Life Cycle, Biology, and Disease. Journal of Parasitology, 89 (4): 658-667.

**INVASIVE ALGAE:**

## Black mat algae

1. Hudon, C., De Seve, M., and Cattaneo, A. 2014. Increasing occurrence of benthic filamentous cyanobacterium *Lyngbya wollei*: a symptom of freshwater ecosystem degradation. Freshwater Science. 33(2): 606-618 <<http://web.b.ebscohost.com.ezaccess.libraries.psu.edu/ehost/pdfviewer/pdfviewer?sid=9dc6c7da-b32d-4f93-a614-dd09161629f2%40sessionmgr113&vid=1&hid=115>>.
2. Joyner, J.J., Litaker, R.W. and Paerl, H.W. 2008. Morphological and Genetic Evidence that the Cyanobacterium *Lyngbya wollei* (Farlow ex Gomont) Speziale and Dyck Encompasses at Least Two Species. Applied and Environmental Microbiology. 74 (12): 3710-3717. <<http://aem.asm.org/content/74/12/3710.full>>.
3. Montgomery, R. 2006. A blue-green Godzilla. Water Quality and Fisheries: BASS Times. <[http://www.westernlakeerie.org/lyngbya\\_godzilla\\_bf\\_0308.pdf](http://www.westernlakeerie.org/lyngbya_godzilla_bf_0308.pdf)>.
4. Ohio Sea Grant. Harmful Algal Blooms in Ohio Waters Fact Sheet. <[http://www.cees.iupui.edu/sites/default/files/2010osgFact\\_HABsV1a.pdf](http://www.cees.iupui.edu/sites/default/files/2010osgFact_HABsV1a.pdf)>.

## Codium

1. Bridgwood, S. 2010. *Codium fragile* ssp. *Fragile* (Suringar) Hariot summary document. Government of Western Australia Department of Fisheries. <[http://www.fish.wa.gov.au/Documents/research\\_reports/fr202.pdf](http://www.fish.wa.gov.au/Documents/research_reports/fr202.pdf)>.
2. Invasive Species Compendium. *Codium fragile* subsp. *Tomentosoides* Datasheet. <<http://www.cabi.org/isc/datasheet/107769>>.
3. The Rhode Island Marine & Estuarine Invasive Species Site. *Codium* species profile. <<http://www.rimeis.org/species/codium.html>>.

## Didymo

1. Shambaugh, A. ANR Confirms First Northeastern U.S. Infestation of 'Didymo'. Vermont Agency of Natural Resources Press Release. <[http://www.northernforestcanoetrail.org/media/rocksnot\\_triver.pdf](http://www.northernforestcanoetrail.org/media/rocksnot_triver.pdf)>.
2. Trout Unlimited. Didymo. Fact sheet. <<http://old.tu.org/science/aquatic-invasive-species-ais/plants/didymo>>.

## Golden alga

1. Harmful Algae Page. Distribution of HABs in the U.S. <<http://www.whoi.edu/redtide/regions/us-distribution>>.

Red alga

1. Frammanderter. 2006. *Gracilaria vermiculophylla* Fact sheet. <[http://www.frammanderter.se/0/2english/pdf/Gracilaria\\_vermiculophylla.pdf](http://www.frammanderter.se/0/2english/pdf/Gracilaria_vermiculophylla.pdf)>.
2. Nettleton, J.C., Mathieson, A.C., Thornber, C., Neefus, C.D., and Yarish, C. 2013. Introduction of *Gracilaria vermiculophylla* to New England, USA: Estimated Arrival Times and Current Distribution. *Rhodora*, 115(961): 28-41.

**INVASIVE REPTILES AND AMPHIBIANS:**

African clawed frog

1. Garvey, N. African Clawed Frog Fact Sheet. University of Michigan Museum of Zoology, Aimal Diversity Web, presented by the Smithsonian National Zoological Park. <<https://nationalzoo.si.edu/Animals/ReptilesAmphibians/Facts/FactSheets/Africanclawedfrog.cfm>>.
2. Willigan, E. 2011. Introduced Species Summary Project: African Clawed Frog (*Xenopus laevis*). Columbia University in the City of New York. <[http://www.columbia.edu/itc/cerc/danoff-burg/invasion\\_bio/inv\\_spp\\_summ/xenopus\\_laevis.htm](http://www.columbia.edu/itc/cerc/danoff-burg/invasion_bio/inv_spp_summ/xenopus_laevis.htm)>.

# Image Credits

## The images in this publication were used courtesy of the following sources:

Bugwood.org (BW), Invasives.org, Encyclopedia of Life (EOL), University of Florida (UFL) Center for Aquatic and Invasive Plants (CAIP) United States Department of Agriculture (USDA) Plants Database (PD), United States Geological Survey (USGS) Non-indigenous Aquatic Species Database (NAS); NOAA Great Lakes Environmental Research Lab (GLERL); Great Lakes Fishery Commission (GLFC); Wikimedia Commons (WMC) and others as listed below.

- Cover: **Red Swamp Crayfish:** WMC; **Yellow Iris:** Elizabeth Sellers, NBII.gov.
- Page 2: Introduction-Sean Kelly, Flickr.
- Page 3: Introduction-**close-up:** Norman E. Rees, USDA Agricultural Research Service (BW); **bottom:** Asian Carp Regional Coordinating Committee, Flickr.
- Page 5: About MAPAIS-**bottom:** Steve Dewey, Utah State University, Bugwood.org.
- Page 8: Prevention-**top:** Jeff Schardt, University of Florida; **bottom:** Pennsylvania Sea Grant.
- Page 9: Prevention-**logo:** Stop Aquatic Hitchhikers
- Page 11: Reporting and Collecting-**lesser celandine:** Leslie J. Mehrhoff, University of Connecticut, Bugwood.org; **asian shore crab:** Ken-ichi Ueda, iNaturalist.org, Eol.

## INVASIVE AQUATIC PLANTS:

- Page 12: Plant structure diagram-UFL CAIP.
- Page 13: Plant structure diagram-UFL CAIP.
- Page 14: Brazilian elodea-**background:** Leslie J. Mehrhoff, University of Connecticut (BW); **line art:** USDA PD.
- Page 15: Brazilian elodea-**U.S. map:** USDA PD; **top:** Richard Old, XID Services Inc. (BW)
- Page 16: Brittle Naiad-**background and line art:** USDA PD.
- Page 17: Brittle Naiad-**top:** Dr. John Hilty, Illinois Wildflowers; **U.S. map:** USDA PD.
- Page 18: Common Salvinia-**background:** Barry Rice, Calphotos (EOL); **line art:** UFL CAIP
- Page 19: Common Salvinia-**U.S. map:** USDA PD; **top:** Barry Rice, Calphotos (EOL).
- Page 20: Creeping water-primrose-**background:** Barry Breckling, Calphotos (EOL); **line art:** USDA PD.
- Page 21: Creeping water-primrose-**top:** Smithsonian Institution (EOL); **U.S. map:** USDA PD.
- Page 22: Curly leaf pondweed-**background:** Chris Evans, River to River CWMA (BW); **line art:** USDA PD.
- Page 23: Curly leaf pondweed-**top:** Richard Old, XID Services, Inc. (BW); **U.S. map:** USDA PD; **bottom:** Chris Evans, River to River CWMA (BW).
- Page 24: Eurasian watermilfoil-**background:** Richard Old, XID Services, Inc. (BW); **line art:** Minnesota Sea Grant.
- Page 25: Eurasian watermilfoil-**top:** Richard Old, XID Services, Inc. (BW); **U.S. map:** USDA PD; **bottom:** Alison Fox, University of Florida (BW).
- Page 26: European Frog-bit-**background:** Leslie J. Mehrhoff, University of Connecticut (BW); **line art:** UFL CAIP.

- Page 27: European Frog-bit-**top**: Leslie J. Mehrhoff, University of Connecticut (BW); **U.S. map**: USDA PD; **bottom**: Louis M. Landry 2006.
- Page 28: European water clover-**background**: John Hilty, Illinois Wildflowers (EOL); **line art**: USDA PD.
- Page 29: European water clover-**top**: Leslie J. Mehrhoff, University of Connecticut (BW); **U.S. map**: USDA PD; **bottom**: Chris Evans, Illinois Wildlife Action Plan (BW).
- Page 30: European water-starwort-**background**: Biopix (EOL); **line art**: Biodiversity heritage library (EOL).
- Page 31: European water-starwort-**top**: Biopix (EOL); **U.S. map**: USDA PD; **bottom**: WMC
- Page 32: Fanwort-**background**: Troy Evans, Eastern Kentucky University (BW); **line art**: USDA PD.
- Page 33: Fanwort-**top**: Leslie J. Mehrhoff, University of Connecticut (BW); **U.S. map**: USDA PD; **bottom**: Troy Evans, Eastern Kentucky University (BW).
- Page 34: Giant salvinia-**background**: Barry Rice, Calphotos (EOL); **line art**: UF CAIP.
- Page 35: Giant salvinia-**top**: Barry Rice, Calphotos (EOL); **U.S. map**: USDA PD; **bottom**: Michael Kesl, Biolib (EOL).
- Page 36: Hydrilla-**background**: Chris Evans, River to River CWMA (BW); **line art**: UF CAIP.
- Page 37: Hydrilla-**top**: Fred Hrusa, CDFA 2011; **bottom**: Wilfredo Robles, Mississippi State University (BW).
- Page 38: Mudmat-**background and close-up**: Robert Capers; **line art**: Patty Wellington, Erie, PA.
- Page 39: Mudmat-**PA and U.S. maps**: USGS NAS; **bottom**: Robert Capers.
- Page 40: Parrot feather-**background**: Alison Fox, University of Florida (BW); **line art**: UF CAIP.
- Page 41: Parrot feather-**top**: Kerry Dressler, UF CAIP; **U.S. map**: USDA PD; **bottom**: Nancy Loewenstein, Auburn University (BW).
- Page 42: Pink Lotus-**background**: maf04, Flickr (EOL); **line art**: USDA PD.
- Page 43: Pink Lotus-**top, U.S. map, and bottom**: USDA PD.
- Page 44: Water chestnut-**background**: Leslie J. Mehrhoff, University of Connecticut (BW); **line art**: USDA PD.
- Page 45: Water chestnut-**top and U.S. map**: USDA PD; **bottom**: Sara Stahlman, Pennsylvania Sea Grant.
- Page 46: Water hyacinth-**background**: Sandino Guerrero, iNaturalist.org (EOL); **line art**: WMC.
- Page 47: Water hyacinth-**top**: Ivo Antusek, Biolib.cz (EOL); **U.S. map**: USDA PD; **bottom**: Mauricio Mercante, Flickr (EOL).
- Page 48: Water lettuce-**background**: Reinaldo Aguilar, Flickr (EOL); **line art**: WMC.
- Page 49: Water lettuce-**top**: Forest and Kim Starr, Biolib.cz (EOL); **U.S. map**: USDA PD; **bottom**: WMC
- Page 50: Waterwheel-**background and line art**: WMC.
- Page 51: Waterwheel-**top and bottom**: WMC; **U.S. map**: USDA PD.
- Page 52: Yellow floating heart-**background**: Biopix (EOL); **line art**: USDA PD.
- Page 53: Yellow floating heart-**top and bottom**: Rob Andress, Alabama DCNR (BW); **U.S. map**: USDA PD.
- Page 54: Yellow iris-**background**: Leslie J. Mehrhoff, University of Connecticut (BW); **line art**: USDA PD.

Page 55: Yellow iris-**top**: Elizabeth Sellers, NBII.gov; **U.S. map**: USDA PD; **bottom**: Nancy Loewenstein, Auburn University (BW).

**INVASIVE WETLAND PLANTS:**

Page 56: Alligatorweed-**background**: WMC; **line art**: USDA PD.

Page 57: Alligatorweed-**top and U.S. map**: USDA PD.

Page 58: Asian spiderwort-**background**: Suzanne Cadwell, iNaturalist.org (EOL); **line art**: USDA PD.

Page 59: Asian spiderwort-**top and U.S. map**: USDA PD; **bottom**: Suzanne Cadwell, iNaturalist.org (EOL).

Page 60: Asiatic sand sedge-**background**: Invasive Plant Atlas of New England; **line art**: plant.ac.cn.

Page 61: Asiatic sand sedge-**top**: Invasive Plant Atlas of New England; **U.S. map**: USDA PD.

Page 62: Beach vitex-**background**: Ahmad Fuad Morad, Flickr (EOL); **labeled image**: David Eickhoff, Flickr (EOL).

Page 63: Beach vitex-**top**: Forest and Kim Starr, Biolib.cz (EOL); **U.S. map**: USDA PD.

Page 64: Common reed (Phragmites)-**background**: Richard Old, XID Services, Inc. (BW); **line art**: USDA PD.

Page 65: Common reed (Phragmites)-**top**: Ken Chamberlain, The Ohio State University (BW); **U.S. map**: USDA PD; **bottom**: John M. Randall, The Nature Conservancy (BW).

Page 66: Flowering rush-**background**: Leslie J. Mehrhoff, University of Connecticut (BW); **line art**: UF CAIP.

Page 67: Flowering rush-**top and bottom**: Leslie J. Mehrhoff, University of Connecticut (BW); **U.S. map**: USDA PD.

Page 68: Garlic mustard-**background**: Rob Routledge, Sault College (BW); **line art**: USDA PD.

Page 69: Garlic mustard-**top**: Steven Katovich, USDA Forest Service (BW); **U.S. map**: USDA PD; **bottom**: BW.

Page 70: Giant hogweed-**background**: Donna.R.Ellis, University of Connecticut; **line art**: <http://mic-ro.com/plants/>.

Page 71: Giant hogweed-**top**: Terry English, USDA APHIS (BW); **U.S. map**: USDA PD.

Page 72: Giant Knotweed-**background**: Tom Heutte, USDA Forest Service (BW); **line art**: Patty Wellington, Erie PA.

Page 73: Giant Knotweed-**top**: Thurston County Washington Noxious Weed Control Agency; **U.S. map**: USDA PD; **bottom**: Tom Heutte, USDA Forest Service (BW).

Page 74: Japanese Hop-**background**: Leslie J. Mehrhoff, University of Connecticut (BW); **line art**: Patty Wellington, Erie, PA.

Page 75: Japanese Hop-**top**: Leslie J. Mehrhoff, University of Connecticut (BW); **U.S. map**: USDA PD; **bottom**: Chris Evans, River to River CWMA (BW).

Page 76: Japanese knotweed-**background**: David J. Moorhead, University of Georgia (BW); **line art**: USDA PD.

Page 77: Japanese knotweed-**top**: Leslie J. Mehrhoff, University of Connecticut (BW); **U.S. map**: USDA PD; **bottom**: Tom Heutte, USDA Forest Service (BW).

Page 78: Japanese stilt grass-**background**: David J. Moorhead, University of Georgia (BW); **line art**: USDA PD.

- Page 79: Japanese stilt grass-**top**: Steve Hurst, USDA NRCS PD (BW); **U.S. map**: USDA PD; **bottom**: Chuck Barger, University of Georgia (BW).
- Page 80: Lesser Celandine-**background**: Leslie J. Mehrhoff, University of Connecticut (BW); **line art**: USDA PD.
- Page 81: Lesser Celandine-**top**: Leslie J. Mehrhoff, University of Connecticut (BW); **U.S. map**: USDA PD; **bottom**: Amadej Trnkoczy, Calphotos (BW).
- Page 82: Mile-a-minute-**background**: Jil M. Swearingen, National Park Service (BW); **line art**: Mary A. Hoffelt, Ohio State University.
- Page 83: Mile-a-minute-**top**: Leslie J. Mehrhoff, University of Connecticut (BW); **U.S. map**: USDA PD; **bottom**: USDA APHIS PPQ Archive (BW).
- Page 84: Moneywort-**background**: Malcom Storey, Biolmages, The Virtual Field Guide UK (EOL); **line art**: USDA PD.
- Page 85: Moneywort-**top and bottom**: WMC; **U.S. map**: USDA PD.
- Page 86: Narrowleaf & hybrid cattails-**background**: Richard Old, XID Services, Inc. (BW); **line art**: USDA PD.
- Page 87: Narrowleaf & hybrid cattails-**top**: Barnes, T.G. and Francis, S.W. 2004. Wildflowers and Ferns of Kentucky, University Press of Kentucky; **U.S. map**: USDA PD; **bottom**: Caryn Green, Blue planet green living.
- Page 88: Poison Hemlock-**background**: WMC; **line art**: USDA PD.
- Page 89: Poison Hemlock-**top**: Malcom Storey, Biolmages, The Virtual Field Guide UK (EOL); **U.S. map**: USDA PD.
- Page 90: Policeman's helmet-**background**: Udo Schmidt, Flickr (EOL); **line art**: Biodiversity Heritage Library (EOL).
- Page 91: Policeman's helmet-**top and U.S. map**: USDA PD; **bottom**: Joe Potter Buttler, iNaturalist (EOL).
- Page 92: Purple loosestrife-**background**: Steve Dewey, Utah State University (BW); **line art**: USDA PD.
- Page 93: Purple loosestrife-**top**: Norman E. Rees, USDA Agricultural Research Service (BW); **U.S. map**: USDA PD; **bottom**: Barry Rice, Sarracenia.com (BW).
- Page 94: Reed canary grass-**background**: Chris Evans, River to River CWMA (BW); **line art**: USDA PD.
- Page 95: Reed canary grass-**top**: Richard Old, XID Services, Inc. (BW); **U.S. map**: USDA PD; **bottom**: Jamie Nielson, University of Alaska Fairbanks, Cooperative Extension Service (BW).
- Page 96: Wavyleaf basketgrass-**background**: WMC; **line art**: Ursula Scholz, Utah State University.
- Page 97: Wavyleaf basketgrass-**top and bottom**: WMC; **U.S. map**: USDA PD.

#### **INVASIVE INVERTEBRATES:**

- Page 98: Invertebrate anatomy-**crayfish**: Doug Jensen, Minnesota Sea Grant; **snail**: Patty Wellington, Erie, PA.
- Page 99: Invertebrate anatomy-**mussel**: Lisa Kanellos, Bivatol.org (EOL); **crab**: Freshwater and marine image bank (EOL).
- Page 100: Asian clam-**background**: Lake George Association; **line art**: Virginia Cooperative Extension, Virginia Tech and Virginia State University.
- Page 101: Asian clam-**top**: Illinois-State University; **U.S. map**: USGS NAS; **bottom**: Shawn Liston, Audubon of Florida (BW).

- Page 102: Asian shore crab-**background**: Jeff Holmes, iNaturalist.org (EOL);  
**labeled image**: USGS NAS.
- Page 103: Asian shore crab-**top**: Foto fitis, Sytske dijksen, Ecomare (EOL); **U.S. map**: USGS NAS.
- Page 104: Australian spotted jellyfish-**background**: WCM; **labeled image**: miloslav petrrly, Biolib.cz (EOL).
- Page 105: Australian spotted jellyfish-**top**: WMC; **U.S. map**: USGS NAS.
- Page 106: Chinese mitten crab-**background**: WMC; **labeled image**: Illinois-Indiana Sea Grant.
- Page 107: Chinese mitten crab-**top**: Christophe Defevre, World Register of Marine Species (EOL);  
**U.S. map**: USGS NAS; **bottom**: WMC.
- Page 108: Chinese pond mussel-**background**: Aleander Mrkvicka (BW);  
**labeled image**: Femorale (EOL).
- Page 109: Chinese pond mussel-**top**: Alexander Mrkvicka (BW); **U.S. map**: USGS NAS.
- Page 110: Faucet snail-**background and labeled image**: Jan Delsing, Biolib.cz (EOL).
- Page 111: Faucet snail-**top**: Biopix (EOL); **U.S. map**: USGS NAS.
- Page 112: Golden mussel-**background**: Wikiwand; **labeled image**: WMC.
- Page 113: Golden mussel-**top**: Gustavo Darrington, Wisconsin Sea Grant; **U.S. map**: cited literature.
- Page 114: Green crab-**background**: iNaturalist.org (EOL); **line art**: Freshwater and marine image bank (EOL).
- Page 115: Green crab-**top**: Biopix (EOL); **U.S. map**: USGS NAS.
- Page 116: Marbled crayfish-**background**: Wikiwand; **labeled image**: Wikipedia.
- Page 117: Marbled crayfish-**top**: Wikipedia; **U.S. map**: cited literature.
- Page 118: Mystery snails-**background**: Illinois-Indiana Sea Grant; **line art**: Patty Wellington, Erie, PA.
- Page 119: Mystery snails-**top and U.S. map**: USGS NAS; **bottom**: College of DuPage.
- Page 120: New Zealand mudsnail-**background and line art**: USGS NAS.
- Page 121: New Zealand mudsnail-**top**: Tim Worsfold, World Register of Marine Species (EOL);  
**U.S. map**: USGS NAS; **bottom**: Minnesota Sea Grant.
- Page 122: Quagga mussel-**background**: Amy Benson, USGS (BW); **line art**: Patty Wellington, Erie, PA.
- Page 123: Quagga mussel-**top**: Michigan Sea Grant; **U.S. map**: USGS NAS; **bottom**: Pennsylvania Sea Grant.
- Page 124: Red swamp crayfish-**background**: WCM; **line art**: Minnesota Sea Grant.
- Page 125: Red swamp crayfish-**top**: Valter Jacinto, Flickr (EOL); **U.S. map**: USGS NAS.
- Page 126: Rusty crayfish-**background and line art**: Jeff Gunderson, Minnesota Sea Grant.
- Page 127: Rusty crayfish-**top**: Cal Vornberger, Animal Diversity, University of Michigan (EOL);  
**U.S. map**: USGS NAS; **bottom**: Keith Pecor, University of Michigan Museum of Zoology.
- Page 128: Spiny waterflea-**background**: M. Gaden, GLFC; **line art**: Minnesota Sea Grant.
- Page 129: Spiny waterflea-**top**: Michigan Sea Grant; **U.S. map**: USGS NAS; **bottom**: US EPA.
- Page 130: Veined rapa whelk-**background**: WMC; **line art**: Femorale (EOL).
- Page 131: Veined rapa whelk-**top and bottom**: WMC; **U.S. map**: USGS NAS.

- Page 132: Virile crayfish-**background**: G. Berry, iNaturalist.org (EOL); **labeled image**: USGS NAS.
- Page 133: Virile crayfish-**top**: Missouri Department of Conservation; **U.S. map**: USGS NAS; **bottom**: WMC.
- Page 134: Zebra mussel-**background**: Randy Westbrooks, USGS (BW); **line art**: Minnesota Sea Grant.
- Page 135: Zebra mussel-**top**: NOAA GLERL; **U.S. map**: USGS NAS; **bottom**: Lubos R. Kolouch (BW).
- INVASIVE MAMMALS AND BIRDS:**
- Page 136: **Feral Hog**: Craig O'Neal, Flickr (EOL).
- Page 137: **Mute Swan-background**: Nick Goodrum, Flickr (EOL); **Nutria-inset**: Steve Kendrot, USDA APHIS3.
- Page 138: Feral Hog-**background**: WMC; **labeled image**: Brian Gratwicke, Flickr (EOL).
- Page 139: Feral Hog-**top**: Smithsonian Wild, Flickr (EOL); **U.S. map**: backcountyattitude.com
- Page 140: Mute Swan-**background**: Jiri Duchon, Biolib.cz (EOL); **labeled image**: James Maughn, iNaturalist.org, Flickr (EOL).
- Page 141: Mute Swan-**top**: WMC; **U.S. map**: Cornell Lab of Ornithology;
- Page 142: Nutria-**background**: Marek Velechovsky, Biolib (EOL); **labeled image**: USGS NAS.
- Page 143: Nutria-**top**: Gustavo Duran (EOL); **U.S. map**: USGS NAS.
- Page 144: Resident Canada Goose-**background**: Eckhard Pecher, ISSG Database (WMC); **labeled image**: ISSG Database (WMC).
- Page 145: Resident Canada Goose-**top**: Andreas Trepte, ISSG Database (WMC); **U.S. map**: Terry Sohl, Nature Serve.
- INVASIVE FISH:**
- Page 146: Fish Anatomy-**line art**: Minnesota Sea Grant; **bottom**: Dave Jude, Michigan Sea Grant.
- Page 147: Fish Anatomy-**tail shapes**: Patty Wellington, Erie, PA.
- Page 148: Asian swamp eel-**background**: Drriss, Flickr (EOL); **line art**: Fish Base (EOL).
- Page 149: Asian swamp eel-**top**: WMC; **U.S. map**: USGS NAS.
- Page 150: Bighead carp-**background**: David Riecks, Illinois-Indiana Sea Grant; **line art**: Michigan Sea Grant.
- Page 151: Bighead carp-**top**: Ontario Ministry of Natural Resources; **U.S. map**: USGS NAS.
- Page 152: Black carp-**background**: Rob Cosgriff, Illinois Natural History Survey; **line art**: Asian carp control website.
- Page 153: Black carp-**top**: Fishbase; **U.S. map**: USGS NAS; **bottom**: Rob Cosgriff, Illinois Natural History Survey.
- Page 154: Blue catfish-**background and line art**: WMC.
- Page 155: Blue catfish-**top**: WMC; **U.S. map**: USGS NAS.
- Page 156: Blue tilapia and redbelly tilapia-**blue tilapia line art**: Fishbase; **redbelly tilapia line art**: WMC.
- Page 157: Blue tilapia and redbelly tilapia-**top**: WMC; **blue and redbelly tilapia U.S. maps**: USGS NAS.
- Page 158: Common carp-**background**: Biopix (EOL); **line art**: Eric Engbretson, U.S. Fish and Wildlife Service (BW).

- Page 159: Common carp-**top**: Biopix (EOL); **U.S. map**: USGS NAS.
- Page 160: European rudd-**background**: Michael Kesi, Biolib.cz (EOL); **line art**: Museum of Comparative Zoology, Harvard University.
- Page 161: European rudd-**top**: Wisconsin Sea Grant; **U.S. map**: USGS NAS; **bottom**: Sean Rafferty, Pennsylvania Sea Grant.
- Page 162: Flathead catfish-**background line art**: Duane Raver, U.S. Fish and Wildlife Service (BW).
- Page 163: Flathead catfish-**top**: Fishbase; **U.S. map**: USGS NAS; **bottom**: Eric Engbretson, U.S. Fish and Wildlife Service (BW).
- Page 164: Goldfish-**background**: Jon Sullivan, Biolib.cz (EOL); **line art**: New York State Department of Environmental Conservation.
- Page 165: Goldfish-**top**: Biopix (EOL); **U.S. map**: USGS NAS.
- Page 166: Grass carp-**background**: Eric Engbretson, U.S. Fish and Wildlife Service (BW); **line art**: Asian carp control website.
- Page 167: Grass carp-**top**: JC Schou, Biopix (EOL); **U.S. map**: USGS NAS; **bottom**: USDA APHIS PPQ Archives (BW).
- Page 168: Ide-**background and line art**: WMC.
- Page 169: Ide-**top**: WMC; **U.S. map**: USGS NAS; **bottom**: Biopix (EOL).
- Page 170: Lionfish-**background**: Mark Rosenstein, iNaturalist.org (EOL); **line art**: Freshwater and marine image bank (EOL).
- Page 171: Lionfish-**top**: Jiri Duchon, Biolib.cz (EOL); **U.S. map**: USGS NAS.
- Page 172: Northern snakehead and blotched snakehead-**labeled background**: USGS Archive (BW); **bottom**: Brian Gratwicke, Flickr (EOL).
- Page 173: Northern snakehead and blotched snakehead-**top**: USGS Archive (BW); **U.S. map**: USGS NAS.
- Page 174: Oriental weatherfish-**background**: Gourami Watcher (WMC); **line art**: Noel Burkhead, Flickr (EOL).
- Page 175: Oriental weatherfish-**top**: New York Department of Environment Conservation Archive (BW); **U.S. map**: USGS NAS; **bottom**: WMC.
- Page 176: Red shiner-**background**: USGS NAS; **line art**: Chad Thomas, Texas State University, San Marcos.
- Page 177: Red shiner-**top**: Chad Thomas, Texas State University, San Marcos; **U.S. map**: USGS NAS; **bottom**: Marine Discover (WMC).
- Page 178: Round goby-**background**: Eric Engbretson, U.S. Fish and Wildlife Service (BW); **line art**: Fishbase.
- Page 179: Round goby-**top**: U.S. Fish and Wildlife Service Archive (BW); **U.S. map**: USGS NAS; **bottom**: Center for Great Lakes and Aquatic Sciences Archive, University of Michigan (BW).
- Page 180: Silver carp-**background**: GLFC; **line art**: Asian carp control website.
- Page 181: Silver carp-**top**: Dan O'Keefe, Michigan Sea Grant; **U.S. map**: USGS NAS; **bottom**: GLFC.
- Page 182: Tubenose goby-**background**: Miloslav Petryl, Biolib.cz (EOL); **line art**: Michigan Sea Grant.
- Page 183: Tubenose goby-**top**: WMC; **U.S. map**: USGS NAS; **bottom**: David Jude, Center for Great Lake and Aquatic Sciences.

### **INVASIVE PATHOGENS:**

- Page 184: Fish Pathogens-**top:** U.S. Fish and Wildlife Service; **bottom:** Mohammed Faisal, USGS.
- Page 185: Fish Pathogens-**top:** Wisconsin DNR; **bottom:** Dr. Paul Bowser, Cornell University.
- Page 186: Common pathogens-**chytrid fungus and eel-swimbladder nematode:** WMC.
- Page 187: Common pathogens-**largemouth bass virus:** Arizona Risk Assessment 2012; **ranavirus:** WMC.
- Page 188: Common pathogens-**spring viremia of carp and viral hemorrhagic septicemia:** WMC.
- Page 189: Common pathogens-**Whirling disease:** WMC.

### **INVASIVE ALGAE:**

- Page 190: Algae Groups-**green:** William Bourland (EOL); **cyanobacteria:** David Patterson (EOL); **golden-brown:** David Patterson and Bob Anderson (EOL); **dinoflagellates:** Maria Faust, Smithsonian Institute (EOL).
- Page 191: Algae Groups-**diatoms:** William Bourland (EOL); **euglenoids:** David Patterson (EOL); **bottom:** New Hampshire Department of Environmental Services.
- Page 192: Black mat alga-**background:** Clemson University.
- Page 193: Black mat alga-**top:** Smithsonian Institution, Museum of Natural History: Department of Botany; **U.S. map:** literature cited.
- Page 194: Codium-**background:** Sarah Carline, iNaturalist.org (EOL).
- Page 195: Codium-**top and bottom:** Wikipedia; **U.S. map:** literature cited; bottom.
- Page 196: Didymo-**background:** Matt Shank, Susquehanna River Basin Commission.
- Page 197: Didymo-**top:** Dr. John Kinross, Napier University; **U.S. map:** USGS National Water Quality Assessment and EPA Environmental Monitoring Assessment.
- Page 198: Golden alga-**background:** Texas Parks and Wildlife
- Page 199: Golden alga-**top and bottom:** Texas Parks and Wildlife; **U.S map:** Texas Parks and Wildlife and PFBC golden alga action plan.
- Page 200: Red alga-**background:** Biopix (EOL).
- Page 201: Red alga-**top and bottom:** Biopix (EOL); **U.S. map:** literature cited.

### **INVASIVE REPTILES & AMPHIBIANS:**

- Page 202: **Turtle Shell Anatomy**-Biodiversity Heritage Library
- Page 203: Frog Anatomy-**frog:** Frog dissection guide; **bottom:** Larry Meade, Flickr.
- Page 204: Red-eared slider-**background and labeled image:** John White, Calphotos.
- Page 205: Red-eared slider-**top:** John White, Calphotos; **U.S. map:** USGS NAS.
- Page 206: African clawed frog-**background:** Brian Gratwicke, Flickr (EOL); **line art:** Pieterse, B. Atlas and Red Data of the Frogs of South Africa, Lesotho, and Swaziland.
- Page 207: African clawed frog-**top:** Department of Natural Heritage Museum, Paris France; **U.S. map:** USGS NAS; **bottom:** Brian Gatwicke, Flickr (EOL).
- Back cover: **Water hyacinth:** Mauricio Mercante, Flickr (EOL); **Mute Swan:** WMC; **African clawed frog:** Animals Wallpapers High Definition website; **Lionfish:** Jiri Duchon, Biolib.cz (EOL).

# Glossary

---

- Achene:** Dry, one-seeded fruit that splits to release the seed
- Adipose fin:** A small, rayless, fleshy dorsal fin present in certain fishes
- Allelopathic (Allelopathy):** The process by which a plant releases chemicals that can inhibit or benefit other plant species
- Allometry (Allometric):** Growth of part of an organism in relation to the growth of the whole organism or some part of it
- Alternate:** Leaves spaced singly along a stem, one at each node
- Anal fin:** An unpaired fin located on the underside of a fish, posterior to the anus
- Anther:** Plant structure located in the stamen (male organ) of the flower that contains the pollen
- Apex:** The tip, point, or peak
- Areola:** A small circular area; small space that separates the carapace in crayfish
- Asexual reproduction:** Mode of reproduction that does not involve meiosis; offspring arise from a single parent and inherit genes only from that parent
- Axil:** The angle formed between two structures on a plant, such as a leaf and a stem
- Basal:** of, at, or forming at the base
- Biofouler:** A living organism whose growth or activity results in the impairment or degradation of something, such as a ship's hull or mechanical equipment
- Bracts:** Small, specialized, leaf-like structures at the base of a flower or leaf
- Bulblet:** A small bulb, or bulb-shaped growth arising from the leaf axil or replacing the flowers; capable of producing a new plant when separated from the parent plant
- Byssal threads:** Strong, silky fibers made from proteins that are used by mussels or other bivalves to attach to rocks, pilings, or other substrates
- Carapace:** A hard, bony or chitinous case or shield covering the dorsal (upper) part of an animal, such as a turtle or crab
- Cationic:** a positively charged ion
- Caudal:** Directed towards the hind part of the body
- Caudal fin:** The tail fin; located at the end of the caudal peduncle and used for propulsion
- Caudal peduncle:** Narrow part of a fish's body to which the caudal or tail fin is attached
- Chelae:** A pincer-like organ or claw found on some arthropods
- Chloroplast:** Specialized organelles found in plant cells and other eukaryotic organisms where photosynthesis occurs
- Cladoceran:** Small crustaceans in the order Cladocera which are commonly found in most freshwater habitats
- Composite flowers:** Large family of flowering plants with individual flowers forming clusters or groups of flowers arranged on a stem, which gives it the appearance of a single flower
- Compound leaf:** A leaf composed of a number of leaflets on a common stalk, arranged either palmately or pinnately
- Conceptacles:** Specialized cavities of marine and freshwater algae that contain the reproductive organs
- Creeping:** Growing by spreading out and staying close to the ground
- Cyanobacteria:** Phylum of bacteria that obtain their energy through photosynthesis
- Deciduous:** Falling off or shedding at a particular season or stage of growth, such as trees shedding their leaves annually
- Detritus:** Non-living, particulate organic material; any disintegrated material or debris

**Dichotomous:** Divided, or branching into two parts

**Dimorphism:** The difference in appearance between males and females of the same species

**Diocious:** Having male and female reproductive organs on separate individuals of the same species

**Diphycercal:** Caudal tail shape; vertebrae extend to the tip of the tail and the tail is symmetrical and expanded

**Diploid:** Having two complete sets of chromosomes

**Dorsal fins:** Are located on the back of a fish and serve to protect against rolling and assist in sudden turns and stops; can have up to three

**Emarginate:** Caudal fin with a slight inward curve

**Emergent:** Plants with leaves that extend above the water surface, usually found in shallow water

**Epilithic:** Growing on the surface of a rock

**Epiphytic:** Growing on another plant

**Flagellum (flagella):** Long, slender, whip-like extensions of certain cells or unicellular organisms, used mainly for movements

**Flanks:** The side of the body between the ribs and the hips

**Fragmentation:** A form of asexual reproduction where an organism is split into fragments that develop into mature, fully grown individuals that are clones of the original organism

**Fronds:** Large or leaf-like part of a palm, fern, or similar plant

**Fruit:** The seed bearing portion of a plant

**Fusiform:** Elongated and spindle-shaped at both ends; fish with this body shape are capable of swimming very fast

**Gonopods:** Specialized appendages of various arthropods used in reproduction or egg-laying

**Haptonema:** A stiff, hair-like organelle attached near the flagella in a group of algae called haptophytes; may function in attachment, feeding, or avoidance

**Hemorrhage:** A profuse discharge of blood, as from a ruptured blood vessel

**Hermaphroditic:** Organism that has reproductive organs associated with both male and female sexes

**Heterocercal:** Caudal tail shape; vertebrae extend into the upper lobe of the tail, making it longer (as in sharks)

**Homocercal:** Caudal tail shape; fin appears superficially symmetric but in fact the vertebrae extend for a very short distance into the upper lobe of the fin

**Hybridization:** The mixing of different species or varieties of animals or plants to produce hybrids of those species

**Inflorescence:** A cluster or arrangement of flowers on an axis

**Keel:** A lateral ridge found on the caudal peduncle of many fast-swimming fishes that provides stability and support to the caudal fin

**Lamina:** A trap-like organ of a plant

**Lateral line:** A series of sensory pores along the head and sides of a fish and some amphibians by which water currents, vibrations, and pressure changes are detected

**Laterally compressed:** Flattened from side to side; fish with this body shape usually do not swim rapidly but have exceptional maneuverability

**Leaflet:** Individual blades found in a compound leaf

**Lemna:** A larger, outer bract which, along with the palea, serves to contain the floret(s) held within and provides a protective covering for the developing floret as well as for the seed after ripening

**Ligule:** Thin, membranous extension of the leaf sheath on the upper surface of the leaf; may be hairy or bristly, hard or soft

- Lunate:** Caudal fin shaped like a crescent moon
- Mandible:** The bone of the lower jaw
- Margin:** The edge or border of something
- Melanize:** To convert into a group of naturally occurring dark pigments called melanin
- Mid-vein (Midrib):** The central vein of a leaf that runs from the tip to the base of the leaf
- Monoecious:** Having male and female reproductive structures on the same plant
- Monotypic:** Having only one type or representative; such as a genus containing only one species
- Morphs:** One of several variant forms of an animal or plant
- Nacre (Mother of pearl):** The hard, pearly, iridescent substance forming the inner layer of a mollusk shell
- Nodes:** A knob, or joint of a stem from which leaves, roots, shoots, or flowers may arise
- Nut/Nutlet:** Dry fruit having a hard shell which usually contains only one seed; nutlets are very small nuts
- Obliterate:** Invisible or indistinct
- Ocrea:** A sheath around a stem or node formed by two or more **stipules**
- Operculum:** A structure that acts as a lid or covering to close the aperture of a mollusk's shell when the animal is retracted
- Opposite:** Two leaves emerging from one node directly across from one another; leaves occurring in pairs
- Palmate:** Having several lobes (typically 5-7) whose mid-ribs all radiate from one common point
- Panicles:** A many branched **inflorescence**
- Parthenogenesis (Parthenogenetic):** Natural form of asexual reproduction in which growth and development of embryos occur without fertilization
- Pelvic fin:** Each pair of fins on the underside of a fish's body, attached to pelvic girdle and helping to control direction
- Perigynium:** A fleshy cup or tube that encloses the female flowers of sedges of the genus *Carex*
- Periostracum:** a thin organic coating which is the outermost layer of the shell of many shelled animals
- Petiole:** A leaf stalk
- Pharyngeal:** Relating to the pharynx, which is the membrane-lined cavity behind the nose and mouth that connects them to the esophagus
- Photosynthesis (Photosynthetic):** The process where green plants and some other organisms use sunlight to synthesize foods from carbon dioxide and water
- Pinnate:** Having leaflets arranged on either side of the stem, typically in pairs opposite each other
- Pistils:** The female fertilizing organs of a flower
- Pistillate:** Having **pistils** (female flowers) but no **stamens** (male flowers)
- Plastron:** The ventral surface of a turtle shell
- Plumage:** a bird's feathers
- Prokaryote:** A microscopic single-celled organism that has neither a distinct nucleus with a membrane nor other specialized organelles
- Protocercal:** Caudal tail shape; vertebrae extend to the tip of the tail and the tail is symmetrical but not expanded
- Protozoan:** A single-celled microscopic animal of a group of phyla of the kingdom Protista
- Quadrifoliate:** Having four leaves or leaflets
- Receptacle:** Thickened part of a stem from which the flower organs grow
- Rhizomes:** A creeping underground stem
- Rosette:** Leaves arranged in a radiating pattern at the base or top of the plant
- Rostrum:** A beak-like projection, especially a stiff snout or anterior prolongation of the head in an insect, crustacean, or cetacean

**Runner:** A slender, creeping stem that puts forth roots from nodes, spaced at intervals along its length; new plants eventually grow from the nodes and can become detached from the parent plant

**Scute:** A thickened horny or bony plate or large scale; such as on the shell of a turtle, underside of a snake, back of a crocodile, etc.

**Sepals:** Part of the outer floral leaves; usually green

**Serrate/Serrated:** A sharply toothed leaf margin

**Sessile:** Sitting directly on a main stem or branch without the support of a leaf stalk

**Sheath:** The extension of the leaf that surrounds the stem

**Spike/Spikelet:** A flower or fruit bearing stalk

**Spire:** A long tapering conical or pyramidal object

**Sporocarp:** specialized type of structure found in some ferns whose primary function is the production and release of spores

**Stalk:** A stem or similar structure that supports a plant part such as a flower, flower cluster, or leaf

**Stamen:** The male fertilizing organ of a flower

**Staminate:** Having stamens (male flowers) but no pistils (female flowers)

**Stolon:** A horizontally creeping stem on the surface of the soil

**Submersed (submerged):** Plants growing with their root, stems, and leaves completely under the surface of the water

**Sutures:** A line or junction of adjacent animal or plant parts such as the juncture between whorls of a mollusk shell, or the junction between the valves of a bivalve shell

**Telson:** The last segment in the abdomen, or terminal appendage in crustaceans, chelicerates, and embryonic insects

**Terminal:** Situated at the end or extremity

**Triactinomyxon:** Spores that live in tubifex worms and can infect other fish with whirling disease

**Triploid:** Containing three homologous sets of chromosomes

**Truncate:** Appearing to end abruptly, shortened, cut off at the end

**Tuber:** The short, thickened, fleshy, food-storing portion of an underground stem with many surface buds; shaped like a tiny potato

**Tubercle:** A small rounded projection, especially on the bone or on the surface of a plant or animal

**Turbidity (turbid):** Muddiness created by stirring up sediment or having foreign particles suspended

**Turion:** A young scaly shoot budded off from underground stems; detachable winter bud used for survival when conditions are unfavorable

**Tussock:** A small hillock of grassy, or grass-like plant growth

**Utricles:** A small cell, sac, or bladder-like protuberance in an animal or plant

**Vegetatively:** A form of asexual reproduction of a plant where new plants grow from parts of the parent plant

**Veliger:** The free-swimming, planktonic larva of certain aquatic mollusks such as zebra mussels

**Ventral:** Relating to the underside of an animal or plant

**Whorl/Whorled:** A pattern of spirals or concentric circles; In plants: an arrangement of three or more leaves, flowers, or bracts radiating from a common node, spread at intervals along the stem.

**Zooxanthellae:** a yellowish-brown symbiotic dinoflagellate present in large numbers in the cytoplasm of many marine invertebrates

# Common Name Index

|                                   |     |                            |     |                                    |     |
|-----------------------------------|-----|----------------------------|-----|------------------------------------|-----|
| African clawed frog.....          | 206 | Fanwort.....               | 32  | Pink lotus.....                    | 42  |
| Alligatorweed.....                | 56  | Faucet snail.....          | 110 | Poison hemlock.....                | 88  |
| Asian clam.....                   | 100 | Feral hog.....             | 138 | Policeman's helmet.....            | 90  |
| Asian shore crab.....             | 102 | Flathead catfish.....      | 162 | Purple loosestrife.....            | 92  |
| Asian spiderwort.....             | 58  | Flowering rush.....        | 66  | Quagga mussel.....                 | 122 |
| Asian swamp eel.....              | 148 | Garlic mustard.....        | 68  | Ranavirus.....                     | 187 |
| Asiatic sand sedge.....           | 60  | Giant hogweed.....         | 70  | Red alga.....                      | 200 |
| Australian spotted jellyfish..... | 104 | Giant knotweed.....        | 72  | Red-eared slider.....              | 204 |
| Beach vitex.....                  | 62  | Giant salvinia.....        | 34  | Red shiner.....                    | 176 |
| Bighead carp.....                 | 150 | Golden alga.....           | 198 | Red swamp crayfish.....            | 124 |
| Black carp.....                   | 152 | Golden mussel.....         | 112 | Reed canary grass.....             | 94  |
| Black mat alga.....               | 192 | Goldfish.....              | 164 | Resident Canada goose.....         | 144 |
| Blue catfish.....                 | 154 | Grass carp.....            | 166 | Round goby.....                    | 178 |
| Brazilian elodea.....             | 14  | Green crab.....            | 114 | Rusty crayfish.....                | 126 |
| Brittle naiad.....                | 16  | Hydrilla.....              | 36  | Silver carp.....                   | 180 |
| Cattails (Narrowleaf & hybrid) .. | 86  | Ide.....                   | 168 | Snakehead (northern & blotched)... | 172 |
| Chinese mitten crab.....          | 106 | Japanese hop.....          | 74  | Spiny waterflea.....               | 128 |
| Chinese pond mussel.....          | 108 | Japanese knotweed.....     | 76  | Spring viremia of carp.....        | 188 |
| Chytrid fungus.....               | 186 | Japanese stilt grass.....  | 78  | Tilapia (blue and redbelly).....   | 156 |
| Codium.....                       | 194 | Largemouth bass virus..... | 187 | Tubenose goby.....                 | 182 |
| Common carp.....                  | 158 | Lesser celandine.....      | 80  | Veined rapa whelk.....             | 130 |
| Common reed (Phragmites).....     | 64  | Lionfish.....              | 170 | Viral hemorrhagic septicemia.....  | 188 |
| Common salvinia.....              | 18  | Marbled crayfish.....      | 116 | Virile crayfish.....               | 132 |
| Creeping water-primrose.....      | 20  | Mill-a-minute.....         | 82  | Water chestnut.....                | 44  |
| Curly-leaf pondweed.....          | 22  | Moneywort.....             | 84  | Water hyacinth.....                | 46  |
| Didymo.....                       | 196 | Mudmat.....                | 38  | Water lettuce.....                 | 48  |
| Eel swimbladder nematode.....     | 186 | Mute swan.....             | 140 | Waterwheel.....                    | 50  |
| Eurasian watermilfoil.....        | 24  | Mystery snails.....        | 118 | Wavyleaf basketgrass.....          | 96  |
| European frog-bit.....            | 26  | New Zealand mudsnail.....  | 120 | Whirling disease.....              | 189 |
| European rudd.....                | 160 | Nutria.....                | 142 | Yellow floating heart.....         | 52  |
| European water clover.....        | 28  | Oriental weatherfish.....  | 174 | Yellow iris.....                   | 54  |
| European water-starwort.....      | 30  | Parrot feather.....        | 40  | Zebra mussel.....                  | 134 |

# Scientific Name Index

|                                     |     |                                  |     |  |     |
|-------------------------------------|-----|----------------------------------|-----|--|-----|
| Aldrovanda vesiculosa .....         | 50  | Gracilaria vermiculophylla ..... | 200 | Oplismenus hirtellus ssp. Undulatifolius.. | 96  |
| Alliaria petiolata .....            | 68  | Hemigrapsus sanguineus .....     | 102 | Orconectes rusticus.....                   | 126 |
| Alternanthera philoxeroides .....   | 56  | Heracleum mantegazzianum.....    | 70  | Orconectes virilis.....                    | 132 |
| Anguillicola crassus.....           | 186 | Humulus japonicus.....           | 74  | Oreochromis aureus.....                    | 156 |
| Batrachochytrium dendrobatidis..... | 186 | Hydrilla verticillata .....      | 36  | Persicaria perfoliata .....                | 82  |
| Bithynia tentaculata.....           | 110 | Hydrocharis morsus-ranae.....    | 26  | Phalaris arundinacea.....                  | 94  |
| Branta canadensis.....              | 144 | Hypophthalmichthys molitrix ..   | 180 | Phragmites australis.....                  | 64  |
| Butomus umbellatus .....            | 66  | Hypophthalmichthys nobilis ..    | 150 | Phyllorhiza punctata .....                 | 104 |
| Bythotrephes longimanus.....        | 128 | Ictalurus furcatus .....         | 154 | Pistia stratiotes .....                    | 48  |
| Cabomba caroliniana.....            | 32  | Impatiens glandulifera .....     | 90  | Potamogeton crispus .....                  | 22  |
| Callitriche stagnalis.....          | 30  | Iridoviridae.....                | 187 | Potamopyrgus antipodarum.....              | 120 |
| Carassius auratus.....              | 164 | Iris pseudacorus.....            | 54  | Procambarus clarkii.....                   | 124 |
| Carcinus maenas .....               | 114 | Leuciscus idus.....              | 168 | Procambarus fallax f. virginialis .....    | 116 |
| Carex kobomugi .....                | 60  | Limnoperna fortunei .....        | 112 | Proterorhinus semilunaris.....             | 182 |
| Channa argus.....                   | 172 | Ludwigia peploides .....         | 20  | Prymnesium parvum .....                    | 198 |
| Channa maculata .....               | 172 | Lyngbya wollei .....             | 192 | Pterois miles .....                        | 170 |
| Cipangopaludina spp. ....           | 118 | Lysimachia nummularia.....       | 84  | Pterois volitans .....                     | 170 |
| Codium fragile ssp. tomentosoides.. | 194 | Lythrum salicaria.....           | 92  | Pylodictis olivaris.....                   | 162 |
| Conium maculatum .....              | 88  | Marsilea quadrifolia.....        | 28  | Ranavirus.....                             | 187 |
| Corbicula fluminea.....             | 100 | Microstegium vimineum.....       | 78  | Ranunculus ficaria .....                   | 80  |
| Ctenopharyngodon idella.....        | 166 | Misgurnus anguillicaudatus ..    | 174 | Rapana venosa .....                        | 130 |
| Cygnus olor .....                   | 140 | Monopterus albus.....            | 148 | Rhabdovirus carpio .....                   | 188 |
| Cyprinella lutrensis.....           | 176 | Murdannia keisak .....           | 58  | Salvinia minima .....                      | 18  |
| Cyprinus Carpio .....               | 158 | Mylopharyngodon piceus.....      | 152 | Salvinia molesta.....                      | 34  |
| Didymopshenia geminata.....         | 196 | Myocastor coypus .....           | 142 | Scardinius erythrophthalmus.....           | 160 |
| Dreissena bugensis.....             | 122 | Myriophyllum aquaticum.....      | 40  | Sinanodontia woodiana.....                 | 108 |
| Dreissena polymorpha .....          | 134 | Myriophyllum spicatum .....      | 24  | Sus scrofa .....                           | 138 |
| Egeria densa.....                   | 14  | Myxobolus cerebralis.....        | 189 | Tilapia zillii.....                        | 156 |
| Eichhornia crassipes.....           | 46  | Najas minor .....                | 16  | Trapa natans .....                         | 44  |
| Eriocheir sinensis .....            | 106 | Nelumbo nucifera .....           | 42  | Trachemys scripta elegans .....            | 204 |
| Fallopia japonica.....              | 76  | Neogobius melanostomus.....      | 178 | Typha angustifolia and Typha x glauca ..   | 86  |
| Fallopia sachalinensis.....         | 72  | Novirhabdovirus sp. ....         | 188 | Vitex rotundifolia .....                   | 62  |
| Glossostigma cleistanthum .....     | 38  | Nymphoides peltata.....          | 52  | Xenopus laevis.....                        | 206 |

## Measurement Conversion

1 centimeter = 0.39 inches

2.5 centimeters = 1 inch

25.4 millimeters = 1 inch

30.5 centimeters = 1 foot

1 meter = 3.28 feet

0.914 meters = 1 yard

**Centimeter Specimen Ruler**





Mid-Atlantic Panel on  
Aquatic Invasive Species

